THERMAL ENGINEERING – I

B.Tech. III Year I Sem.
Course Code: ME502PC

L	T/P/D	C
4	1/0/0	4

Pre-requisite: Thermodynamics

Course Objective: To apply the laws of Thermodynamics to analyze air standard cycles and to understand and evaluate the perform analysis of the major components and systems of IC engines, refrigeration cycles and their applications.

Course Outcomes: At the end of the course, the student should be able to evaluate the performance of IC engines and compressors under the given operating conditions. Apply the laws of Thermodynamics to evaluate the performance of Refrigeration and air-conditioning cycles. Understand the functionality of the major components of the IC Engines and effects of operating conditions on their performance

UNIT – I

I.C. Engines: Classification - Working principles of Four & Two stroke engine, SI & CI engines, Valve and Port Timing Diagrams, Air – Standard, air-fuel and actual cycles - Engine systems – Carburetor and Fuel Injection Systems for SI engines, Fuel injection systems for CI engines. Ignition, Cooling and Lubrication system, Fuel properties and Combustion Stoichiometry.

UNIT – II

Normal Combustion and abnormal combustion in SI engines – Importance of flame speed and effect of engine variables – Abnormal combustion, pre-ignition and knocking in SI Engines – Fuel requirements and fuel rating, anti knock additives – combustion chamber – requirements, types of SI engines.

Four stages of combustion in CI engines – Delay period and its importance – Effect of engine variables – Diesel Knock– Need for air movement, suction, compression and combustion induced turbulence in Diesel engine – open and divided combustion chambers and fuel injection– Diesel fuel requirements and fuel rating

UNIT - III

Testing and Performance: Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and indicated power – Performance test – Heat balance sheet and chart

Classification of compressors – Fans, blowers and compressors – positive displacement and dynamic types – reciprocating and rotary types.

Reciprocating Compressors: Principle of operation, work required, Isothermal efficiency volumetric efficiency and effect of clearance volume, staged compression, under cooling, saving of work, minimum work condition for staged compression

UNIT – IV

Rotary Compressor (Positive displacement type): Roots Blower, vane sealed compressor, Lysholm compressor – mechanical details and principle of working – efficiency considerations.

Dynamic Compressors: Centrifugal compressors: Mechanical details and principle of operation – velocity and pressure variation. Energy transfer-impeller blade shape-losses, slip factor, power input factor, pressure coefficient and adiabatic coefficient – velocity diagrams – power.

Axial Flow Compressors: Mechanical details and principle of operation – velocity triangles and energy transfer per stage degree of reaction, work done factor - isentropic efficiency- pressure rise calculations – Polytropic efficiency.

UNIT – V

Refrigeration: Mechanical Refrigeration and types – units of refrigeration – Air Refrigeration system, details and principle of operation – applications of air refrigeration, Vapour compression refrigeration systems – calculation of COP – effect of superheating and sub cooling, desired properties of refrigerants and common refrigerants- Vapour absorption system – mechanical details – working principle, Use of p-h charts for calculations

Air-Conditioning: Concepts of Psychrometry – Properties of moist air – Usage of Psychrometric Chart – Calculation of moist air properties.

Types of air – conditioning systems – Requirements - schematic layout of a typical plant.

TEXT BOOKS:

1. I.C. Engines / V. Ganesan / Mc Graw Hill
2. Thermal Engineering / Mahesh M Rathore / Mc Graw Hill

REFERENCE BOOKS:

1. Applied Thermodynamics for Engineering Technologists / Eastop / Pearson
2. Fundamentals of Classical Thermodynamics / Vanwylen G.J., Sonntag R.E. / Wiley Eastern

LESSON PLAN

Staff Name : P. Sreenivasulu Department : Mechanical :

Class : B.Tech. Subject : TE-I Semester : I Branch : Mech. Section : A Year : III

Annamacharya Institute of Technology & Sciences BatasingaramHyderabad
Department of Mechanical Engineering
Lesson Plan
B-Tech MECH (III) SEM-II: THERMAL ENGINEERING-IAcademicyear: 2019-2020
Name of the staff member : P. Sreenivasulu.

S.No	Unit No	Date	Topic	No Of Periods	Cumulative periods
1	I		**INTRODUCTION TO I.C.ENGINES:**	1	1
2			FOUR STOKE ENGINE -SI AND CI ENGINE	1	2
3			TWO STROKE ENGINE-SI AND CI ENGINE	1	3
4			VLAVE TIMING DIAGRAM-SI ENGINE AND CI ENGINE	1	4
5			PORT DIAGRAM-SI AND CI ENGINE	1	5
6			FUEL INJECTION SYSTEMS FOR CI ENGINES AND SI ENGINE	2	7
7			IGNITION FOR SI ENGINE	2	9
8			COOLING AND LUBRICATION SYSTEM	2	11
9			FUEL PROPERTIES AND COMBUSTION STIOCHIOMETRY	2	13
10	II		**COMBUSTION IN SI AND CI ENGINES:** NORMAL COMBUSTION AND ABNORMAL COMBUSTION IN SI ENGINE	2	15
11			IMPORTANCE OF FLAME SPEED AND EFFECT OF ENGINE VARIABLES	1	16
12			ABNORMAL COMBUSTION,PRE-IGNITION AND KNOCKING IN SI ENGINES	2	18
13			FUEL REQUIREMENTS AND FUEL RATING	1	19
14			ANTI KNOCK ADDITIVES COMBUSTION CHAMBER,REQUIREMENTS	1	20
15			TYPES OF SI ENGINES	1	21
16	III		**TESING AND PERFORMANCE OF ENGINES AND COMPRESSORS;** MEASERMENT OF CYLINDER PRESSURE	2	23
17			FUEL CONSUMTPION,AIR INTAKE	1	24
18			EXHAUST GAS COMPOSITION	2	26
19			BRAKE POWER	1	27
20			PERFORMANCE TEST	2	29
21			HEAT BALANCE SHEET AND CHART	2	31
22			CLASSIFICATION OF COMPRESSORS,FANS,BLOWERS AND COMPRESSORS	1	32
23			POSITIVE DISPLACEMENT AND DYNAMIC TYPES,	1	33
24			RECIPROCATING AND ROTARY TYPES	1	34
25	IV		**ROTARY DYNAMIC AND AXIAL FLOW(POSITIVE DISPLACEMENT TYPE):**	1	35
26			ROOTS BLOWER, MECHANICAL DETAILS AND PRINCIPLE OF WORKING	1	36
27			VANE SEALED COMPRESSOR MECHANICAL DETAILS AND PRINCIPLE OF WORKING	1	37

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LESSON PLAN

Staff Name : P. Sreenivasulu Department : Mechanical

Class : B.Tech Subject : TE-I Semester : I Branch : Mech Section : A Year : IV

28			LYSHOLM COMPRESSOR MECHANICAL DETAILS AND PRINCIPLE OF WORKING	1	38
29			EFFICIENCY CONSIDERATIONS.	2	40
30			**CENTRIFUGAL COMPRESSOR:** MECHANICAL DETAILS AND PRINCIPLE OF OPERATION	1	41
31			VELOCITY AND PRESSURE VARIATION	1	42
32			ENERGY TRANSFER-IMPELLER BLADE SHAPE LOSSES,SLIP FACTOR	1	43
33			POWER INPUT FACTOR,PRESSURE COEFFICIENT AND ADIABATIC COEFFICIENT	1	44
34			VELOCITY DIAGRAMS-POWER.,MECHANICAL DETAILS AND PRINCIPLE OF OPERATION-	2	46
35			VELORCITY TRIANGLES AMD ENERGY TRANSFER PER STAGE DEGREE OF REACTION	2	48
36			WORK DONE FACTOR, ISENTROPIC EFFICIENCY	2	50
37			PRESSURE RISE CALCULATIONS ,POLYTROPIC EFFICIENCY	2	52
38	V		**REFRIGERATION:** AIR REFRIGERATION SYSTEM,DETAILS AND PRINCIPLE OF OPERATION, APPLICATIONS OF REFRIGERATION	2	54
39			VAPOUR COMPRESSION REFRIGERATION SYSTEMS	2	56
40			CALCULATION OF COP	2	58
41			EFFECT OF SUPER CHARGING AND SUBCOOLING	2	60
42			DESIRED PROPERTIES OF REFRIGERANTS AND COMMON REFRIEGERANTS	1	61
43			VAPUOR ABSORPTION SYSTEM, MECHANICAL DETAILS,WORKING PRINCIPLES	2	63
44			USE OF P-H CHARTS FOR CALCUALATIONS.	2	65

Faculty name: P. Sreenivasulu HOD: Principal:

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TD SET-I

1	Explain with a neat sketch the construction details of I.C engine mechanism and name the principal components
2.	With neat sketches, explain the working principle of Four Stroke Spark Ignition Engine
3	Compare and contrast the differences between S.I Engine with C.I Engine
4	Explain the Valve Timing Diagram of Four Stroke Diesel Engine with diagram.

TD SET-II

1	Explain the working principle of two stroke S.I engine with a diagram
2.	Explain the working of a Four Stroke C.I Engine with a neat sketch
3	Compare and contrast the differences between Four-stroke Cycle Engine and Two-Stroke Cycle Engine
4	Explain the Port Timing Diagram for 2-Stroke Diesel Engine with diagram

TD SET-III

1	Steam at 20 bar,360 deg C, is expanded in a steam turbine to 0.08 bar.It then enters a condensor where it is condensed to saturated liquid water.The pump feed back the water into the boiler(a) assuming ideal process.find per kg of steam the network and the cycle efficiency
2.	In a Steam Power Plant,the steam enter the turbine at 30 bar and 350 Deg C, and is condensed in the condenser at a pressure of0.75 bar.Determine the efficiency of Rankine Cycle considering the pump work
3	Give the comparison between fire tube and water tube boilers
4	Explain simple Babcock and Wilcox water tube boiler with Neat Sketch?

TD SET-IV

1	In an Ideal Rankine cycle steam at 150 bar and 500 deg C, enters the turbine and the condenser operates at 10 KPa.If the power output of the cycle is 100 MW .Determine 1) The Mass flow of Steam 2.) Thermal Efficiency of the cycle
2.	In a Rankine Cycle,the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar.Determine 1)The Pump Work 2)The Turbine Work 3) The Rankine Efficiency
3	How are the steam boilers classified?
4	State and describe the working of Lancashire boiler

Set.4.

Set.1. Objective Question

1. For an efficient I.C engine,the thermal efficiency at a rated load ranges between.

( )

a) 10 to 20% b) 30 to 35 %

c) 65 to 70% d) 80 to 90%

2. The mass of exhaust gases is the, ( )

a) Mass of fuel supplied b) Mass of air supplied

c) Masses of air and fuel supplied d) None of the above

3.A reciprocating compressor is a type of, ( )

a) Positive displacement b) Negative Displacement

c) Dynamic action type d) None of the above

4. Fuel consumption against brake power in a diesel engine is, ( )

a) Linear b) Hyperbolic

c) Parabolic d) Not predictable

5 The ideal work of compressing 1 kg of air with an increase in clearance volume

( )

a) Increases b) Decreases

c) First increases then decreases d) Remains same

6) The C.O.P is always _____one ( )

a) Less than b) Greater than

c) Equal to d) None of the above

7) In a domestic vapour compression system,the commonly used refrigerant is, ( )

a) SO_2 b) CO_2

c) Ferron-12 d) NH_3

8) The centrifugal and axial flow compressor are the types of ( )

a) displacement compressor

b) steady-flow compressor

c) both of the mentioned

d) none of the mentioned

9) The compressor shows cyclic and back flow of compressed air during, ( )

a) Pressure coefficient b) Choking

c) Surging d) None of the above

10) During a refrigeration process,the heat is rejected in _____by the refrigerant ( )

a) Condenser b) Compressor

c) Expansion valve d) Evaporator

II. Fill in the blanks 10x1/2=5M

1) Mechanical efficiency is defined as the ratio of _____and _____
2) The performance of an engine is generally given by _____
3) The function of a _____ is to take a definite amount of air and deliver it adesired pressure
4) _____ is a machine used for compressing low pressure air and delivering it h igh pressure
5) The roots blower compressor is used for _____and_____of two -stroke engines.
6) In vane type of compressor the inlet passage is _____than outlet passage.
7) The compressors that are used for producing medium pressure gas is _____
8) The method of cooling or removing heat from a system is known as _____
9) The C.O.P is always _____one.
10) During a refrigetaion cycle,heat is rejected by the _____in a condenser.

Set.2.

1. The intake charge in a diesel engine consists of ( )

a) air alone b) air + lubricating oil

c) air + fuel d) air + fuel + lubricating oil

2. Gudgeon pin forms the link between ( )

a) piston and big end of connecting rod

b) piston and small end of connecting rod

c) connecting rod and crank

d) big end and small end

3.In a four-stroke engine cam shaft rotates at ( )

a) same speed as crankshaft

b) twice the speed of crankshaft

c) half the speed of crankshaft

d) none of the above

4. Thermal efficiency of CI engine is higher than that of SI engine due to ( )

a) fuel used

b) higher compression ratio

c)constant pressure heat addition

d) none of the above

5.SI engines are ( )

a) light weight

b) high speed

c) homogeneous change of fuel and oil

d) all of the above

6. Compression ratio in diesel engine is of the order of ( )

a) 5-7 b) 7-10

c) 10-12 d) 14-20

7.Main advantage of a two- stroke engine over four-stroke engine is ( )

a) more uniform torque on the crankshaft

b) more power output for the cylinder of same dimensions

c) absence of valves

d) all of the above

8. Engines used for ships are normally

a) four-stroke SI engines of very high power

b) two-stroke CI engines of very high power

c) four-stroke CI engines of high speed
d) two-stroke SI engines of high power

9.The volumetric efficiency of the SI engine is comparatively ( )
a) lower than CI engine
b) higher than CI engine
c) will be same as CI engine
d) none of the above

10.In a two stroke engine,the working cycle is completed in, ( )
a) One revolution of crankshaft b) Two revolution of crankshaft
c) Three revolution of crankshaft d) Four revolution of crankshaft

II. Fill in the blanks 10x1/2=5M

1. Thermal efficiency of a two stroke engine is _____a four stroke engine.
2. Carburettor is used _____ engines
3. During starting, the rich fuel-air ratio is needed in _____ engine.
4. During suction stroke, in a four stroke engine _____ is sucked inside cylinder
5. A _____ maintains constant speed and stores excess energy.
6. In a four stroke engine, the camshaft runs at _____the speed of crankshaft
7. The working pressure and temperature inside the cylinder is _____in I.C.engines.
8. The consumption of lubricating oil is large in a _____engine
9. A _____ is considered as heart of an I.C engine
10. During starting, the rich fuel-air ratio is needed in _____engine

Code No: 114DU **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B.Tech II Year II Semester Examinations, May - 2017
THERMAL ENGINEERING – I
(Common to ME, AME)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART- A

(25 Marks)

1.a)	What are the different strokes in two stroke engines.	[2]
b)	List out the differences between the SI engine and CI engine.	[3]
c)	What is meant by Cetane number?	[2]
d)	Describe the three desirable properties of CI engine fuels.	[3]
e)	What is the importance for measurement of exhaust gas temperature?	[2]
f)	List out the functions of compressors.	[3]
g)	On which principle the centrifugal pump works.	[2]
h)	Explain the importance of slip factor in compressor.	[3]
i)	What is meant by tonne of refrigeration?	[2]
j)	List out the advantages of air refrigeration.	[3]

PART-B

(50 Marks)

2.a) How does the Zenith carburetor fulfill the requirements of a good carburetor.
b) Explain the working of battery ignition system with the neat sketch. [5+5]

OR

3.a) Explain the working of solid injection system with neat sketch.
b) Explain the working of splash lubricating system with neat sketch. [5+5]

4.a) Briefly explain the stages of combustion in SI engines elaborating the flame front propagation.
b) Explain the effect of various engine variables on SI engine knock. [5+5]

OR

5.a) What are the methods to be followed to avoid knocking in SI engine.
b) What are anti knock agents? Indicate the substances used and their effects on reducing of knocking. [5+5]

6. During a test on a diesel engine the following observations were made:
The power developed by the engine is used for driving a D.C. generator. The output of the generator was 210 A at 200V; the efficiency of generator being 82%.The quantity of fuel supplied to the engine was 11.2 kg/h; calorific value of fuel being 42600kJ/kg. The air-fuel ratio was 18:1. The exhaust gases were passed through a exhaust gas calorimeter for which the observations were as follows:
Water circulated through exhaust gas calorimeter = 580 liters/hr. Temperature rise of water through calorimeter=36^0C. Temperature of exhaust gases at exit from calorimeter=98^0C. Ambient temperature=20^0C.
Heat lost to jacket cooling water is 32% of the total heat supplied.
If the specific heat of exhaust gases be 1.05kJ/kg K. Draw up the heat balance sheet on minute basis. [10]

OR

7.a) Explain the air box method for the measurement of air consumption in internal combustion engine.

b) A six cylinder, 4 stroke SI engine having a piston displacement of 700cm^3 per cylinder developed 78kW at 3200r.p.m. and consumed 27 kg of petrol per hour. The calorific value of petrol is 44 MJ/kg. Estimate:
i) The volumetric efficiency of the engine if the air-fuel ratio is 12 and intake air is at 0.9 bar, 32^0C ii) The brake thermal efficiency iii) The brake torque
For air, R=0.287kJ/kg K. [5+5]

8. A centrifugal compressor running at 8000 rpm delivers 660m^3/min of free air. The air is compressed from 1.01 bar and 15^0C to a pressure of 3 with an isentropic efficiency of 80%. Blades are radial at outlet of impeller and flow velocity of 60 m/s may be assume throughout constant. The outer radius of impeller is thrice the inner and the slip factor may be assumed as 0.8.The blade area coefficient may be assumed 0.8 at inlet. Calculate:
a) Final temperature of air b) Theoretical power c) Impeller diameters at inlet and outlet d) Breadth of impeller at inlet e) Impeller blade angle at inlet f) Diffuser blade angle at inlet. [10]

OR

9.a) Explain the working of roots blower compressor with neat sketch.

b) A centrifugal compressor delivers 50 kg of air per minute at a pressure of 2 bar and 97^0 C. The intake pressure and temperature of air is 1 bar and 15^0C. If no heat is lost to the surrounding, find: i) index of compression ii) Power required, if the compression is isothermal, Take R=287/kg K. [5+5]

10.a) Explain the working of Vapour compression refrigeration system with a neat diagram.

b) A Carnot cycle machine operates between the temperature limits of 47^0C and -30^0C. Determine the COP when it operates as i) refrigerating machine ii) A heat pump iii) A heat engine. [5+5]

OR

11.a) Explain the working of vapour absorption system with neat sketch.

b) A Bell-Coleman refrigerator works between 4 bar and 1 bar pressure limits. After compression, the cooling water reduces the air temperature to 17^0C. What is the lowest temperature produced by the ideal machine?
Compare the coefficient of performance of this machine with that of the ideal Carnot cycle machine working between the same pressure limits, the temperature at the beginning of compression being -13^0 C. [5+5]

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Code No: 114DU **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B.Tech II Year II Semester Examinations, October/ November- 2016
THERMAL ENGINEERING – I
(Common to ME, AME)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A.
Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART- A

(25 Marks)

1.a)	What are the different compositions of CNG?	[2]
b)	Explain what is meant by cruising range?	[3]
c)	What is meant by equivalence ratio and give its significance?	[2]
d)	What is meant by cetane number? Give the details.	[3]
e)	Why retardation test is conducted?	[2]
f)	Explain the significance of Sankey diagram in engine performance parameters.	[3]
g)	Give the working details of roots blower.	[2]
h)	Explain the concept of slip factor in centrifugal compressor.	[3]
i)	What is meant by deuce air refrigeration system and when it is used?	[2]
j)	Explain the effect of liquid sub cooling on the refrigerating effect.	[3]

PART-B

(50 marks)

2.a) What is the purpose of venture in SI engine fuel supply system?
b) Draw the neat sketch and explain the working of carter carburettor. [5+5]

OR

3.a) Draw the line diagram and explain typical fuel feed system for a CI engine.
b) Compare and contrast dry sump lubrication and crank case ventilation. [5+5]

4.a) What is meant by flame speed and how to measure it?
b) What is meant by knock in SI engines and what are the parameters are causing their effect on it? [5+5]

OR

5.a) What is meant by ignition delay in CI engines and explain it with p-Θ diagram.
b) At least two combustion chambers required in CI engines represent by line diagram and explain its working. [5+5]

6.a) Explain the details of exhaust gas composition with the percentage of each component.

b) A four cylinder, four stroke petrol engine has a 10 cm bore, 15 cm stroke and uses a compression ratio of 6. The engine develops 25 kW indicated power at 2000 rpm. Find the mean indicated pressure and air standard efficiency. Also calculate the fuel consumption per hour, if the indicated thermal efficiency is 30%. Take the calorific value of fuel as 42 MJ/kg. [5+5]

OR

7.a) Compare and contrast fans, blowers and compressors.

b) A single acting, single cylinder reciprocating air compressor is compressing 20 kg/min. of air from 110kPa. 30^0C to 600 kPa and delivers it to a receiver. Law of compression is $pV^{1.25}$ = constant. Mechanical efficiency is 80%. Find the power input to compressor, neglecting losses due to clearance, leakages and cooling. [5+5]

8.a) Classify the Rotary compressors and give the salient features.

b) 1 kg of air per second is taken into a root blower compressor at 1 bar and 27^0C. The delivery pressure of air is 1.5 bar. Calculate the motor power required to run the compressor; if mechanical efficiency is 80%. [5+5]

OR

9.a) Explain the concept of stalling and losses of axial flow compressor.

b) An axial flow compressor draws air at 20^0C and delivers it at 50^0C. Assuming 50% reaction, calculate the velocity of flow, if blade velocity is 100 m/s, work factor is 0.85. Take Cp=1kJ/kg.K. Assume $\alpha=10^0$, and $\beta=40^0$, Find the number of stages. [5+5]

10.a) Draw the line diagram and explain the working of Bell Coleman cycle and derive for COP of the same.

b) Air enters the compressor of an air craft cooling system at 100kPa, and 283K. Air is now compressed to 2.5 bar with an isentropic efficiency of 72%. After being cooled to 320K at constant pressure in a heat exchanger, the air then expands in a turbine to 1 bar with an isentropic efficiency of 75%. The cooling load of the system is 3 tonnes of refrigeration. After absorbing heat at constant pressure, the air re-enters the compressor, which is driven by the turbine, Find the COP of the refrigerator, driving power required and air mass flow rate. [5+5]

OR

11.a) Explain the working of an ideal vapour compression refrigeration cycle.

b) A refrigerator used R-12 as a working fluid and it operates on an ideal vapour compression cycle. The temperature of refrigerant in the evaporator is -20^0C and in the condenser is 40^0C. The refrigerant is circulated at the rate of 0.03 kg/s. Determine the coefficient of performance and capacity of refrigeration plant in the TR. [5+5]

THERMODYNAMIC Systems

Closed :- The System in which mass (-ve) and energy (+ve)

Open :- " " " " mass (+ve) and energy (+ve)

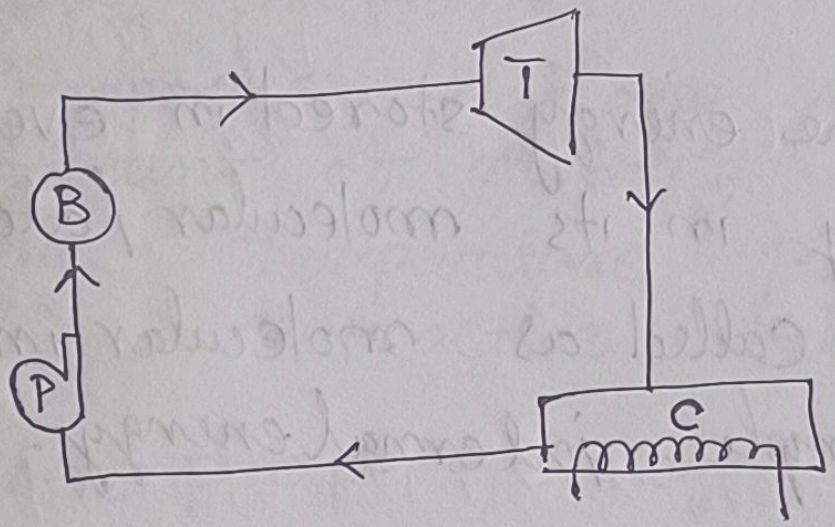
Isolated :- " " " " mass (-ve) and energy (+ve)

+ve → crosses boundary
-ve → doesn't crosses boundary

closed :- Ordinary water bottle

Isolated :- Thermoflask

Open :- Tea in a Cup.



THERMODYNAMIC PROPERTIES

Intensive properties & Extensive properties

State of system

SOME System Properties

Pressure: It is the force upon area. It is the normal force exherted by the system molecules per unit area of the bounding surface.

Temperature: It is a thermodynamic parameter that determines the thermal state of a body i.e. wheather a body will receive or reject heat.

It is also a measure of the avarage molecular K.E. of a body.

Internal Energy: The energy stored in every molecule of system / body in its molecular / atomic structure is generally called as molecular internal engy or simple internal energy.

volume: It is a measure of 3D space surrounded / occupied by the body / system.

Enthalpy: Enthalpy of a system is the mathematical combination of its internal energy and flow energy.

Flow energy / Flow work :

The work needed to push the fluid into or out of the boundary of control volume if the mass flow is involved.

Flow work is necessary for mantaing a continuous flow through a control volume.

Entropy: It is a measure of molecular disorder. -ness or molecular randomness

A thermodynamic property describing the unavailability of system's thermal energy for conversion into mechanical work.

CLASSIFICATION OF PROPERTIES :

Intensive properties :-

Properties that are not depended upon the amount of matter content in system.

e.g. Temperature, pressure, density, refractive index

Extensive properties :-

Properties that are depended upon the amount of matter contained in the body / system is called extensive properties.

e.g. mass, volume, enthalpy, entropy, internal energy etc.

OTHER TERMINOLOGIES

State : It is the condition of system at an instant time which is defined by its properties like P, V, T, etc.

Process : The system undergoes change of state due to energy & mass interaction with surroundings.

The method by which this change occures in system is called a process.

e.g. Const. volume process (Iso-choric process)

The process may be of flow type or non-flow type. In flow process mass transfer occures across boundary of system & in case of non-flow process mass transfer doesn't occure in the boundry e.g. heating of gas in a closed cylinder.

Control volume is similar to open system its more like boundary of the open system is known as Control volume.

[ET - P. Chattopadhyay Page - 4]

& Control mass is similar to closed system.

Path: A path is the loci of various intermidiate states a system is passed through during a process.

Therefore a path represents the succession of states passed through a change of state.
If a path is completely specified it is called a process. e.g. Iso thermal (Constant temperature)

STATE FUNCTION / POINT FUNCTION:

Thermodynamic properties are the point functions for a given state where there is one & only one value for each properties

Such type of properties are located on a graph by means of any 2 thermodynamic properties as a point. As their value changes their ~~value~~ location on the property co-ordinate changes since its only a point.

$$\int_1^2 dV = V_2 - V_1 \qquad \int_1^2 dP = P_2 - P_1$$

change in parameter depends only on final value - initial value.

They are also called state-functions.

PATH FUNCTION:

There are certain quantities which cannot be located on a graph by point but are given by area under the graph. Such quanti is called a path function.

Ex- Heat & Work.

Their differential are denoted by $\bar{D}$ opera instead of 'd' because of 'inexactness' nature.

i.e. like volume, Pressure, Temperature, change in work or heat are not dependent upon the initial or final value rather depended upon the nature of process the system follows.

$$\delta Q, \delta W$$

These Heat, Work & path function are not properties of System.

In cycle inital & final points are one.

So $\oint dV = \oint dp = \oint dT = \oint d(\text{any property})$

$= 0$;

but $\oint \delta W \neq 0$

$\oint \delta Q \neq 0$ as they are not properties.

rather $\oint \delta W$ = Area enclosed by the cycle curve. (P-V)

Process classified as reversible / Irreversible

Reversible process :

Reversible process is a process which is performed in such a way that at the conclusion of process the system & surrounding will come back to initial state by reversing the process, without producing any change to universe.

A reversible process is carried out infinitisely slowly so that every state it passes through is quasistatic or point of equilibrium.

Reversible process in TD

≠ Reversible reaction in chemical reaction.

Reversible process means a process free of loss of energy.

Irreversibility

↳ External → Due to finite temperature difference

↳ Internal → Due to mechanical friction viscous effect.

Irreversibility is linked with entropy; which will be discussed later.

SYLLABUS

DESIGN OF MACHINE MEMBERS - I

B.Tech. III Year I Sem.
Course Code: ME501PC

L	T/P/D	C
4	1/0/0	4

Note: Design Data books are not permitted in the Examinations. The design must not only satisfy strength criteria but also rigidity criteria.

Pre-requisites: Engineering mechanics, mechanics of solids, manufacturing processes, metallurgy and material science.

Course Objectives:

- To understand the general design procedures and principles in the design of machine elements.
- To study different materials of construction and their properties and factors determining the selection of material for various applications.
- To determine stresses under different loading conditions.
- To learn the design procedure of different fasteners, joints, shafts and couplings.

Course Outcomes:

- The student acquires the knowledge about the principles of design, material selection, component behavior subjected to loads, and criteria of failure.
- Understands the concepts of principal stresses, stress concentration in machine members and fatigue loading.
- Design on the basis of strength and rigidity and analyze the stresses and strains induced in a machine element.

UNIT – I

Introduction: General considerations in the design of Engineering Materials and their properties – selection –Manufacturing consideration in design. Tolerances and fits –BIS codes of steels.

Design for Static Strength: Simple stresses – Combined stresses – Torsional and Bending stresses – Impact stresses – Stress strain relation – Various theories of failure – Factor of safety – Design for strength and rigidity – preferred numbers. The concept of stiffness in tension, bending, torsion and combined situations.

UNIT – II

Design for Fatigue Strength: Stress concentration–Theoretical stress Concentration factor– Fatigue stress concentration factor- Notch Sensitivity – Design for fluctuating stresses – Endurance limit – Estimation of Endurance strength – Gerber's curve– Modified Goodman's line– Soderberg's line.

UNIT – III

Riveted, Welded and Bolted Joints: Riveted joints- methods of failure of riveted joints-strength equations-efficiency of riveted joints-eccentrically loaded riveted joints.
Welded joints-Design of fillet welds-axial loads-circular fillet welds under bending, torsion. Welded joints under eccentric loading.
Bolted joints – Design of bolts with pre-stresses – Design of joints under eccentric loading – locking devices – bolts of uniform strength.

UNIT – IV

Keys, Cotters and Knuckle Joints: Design of keys-stresses in keys-cottered joints-spigot and socket, sleeve and cotter, jib and cotter joints-Knuckle joints.

UNIT – V

Shafts: Design of solid and hollow shafts for strength and rigidity – Design of shafts for combined bending and axial loads – Shaft sizes – BIS code. Use of internal and external circlips, Gaskets and seals (stationary & rotary)
Shaft Couplings: Rigid couplings – Muff, Split muff and Flange couplings. Flexible couplings – Flange coupling (Modified).

TEXT BOOKS:

1. Design of Machine Elements / V. Bhandari / Mc Graw Hill
2. Machine Design / Jindal / Pearson

REFERENCE BOOKS:

1. Design of Machine Elements / V. M. Faires / Macmillan
2. Design of Machine Elements-I / Annaiah, M.H / New Age

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LESSON PLAN

Staff Name : Upendar R Department : MECHANICAL.

Class : III B.Tech Subject : DMM-I Semester : I Branch : ME Section : A Year : 2019-20

Sl. No.	Unit No.	Date	Topics to be covered	No. of periods Required	Cumulative Periods

ANNAMACHARYA INSTITUTE OF TECHNOLOGY & SCIENCES
DEPARTMENT OF MECHANICAL ENGINEERING
LESSON PLAN

B.Tech III Year I Semester **Academic year: 2019-20**

Name of the staff member : **UPENDAR R**

SUBJECT: **DESIGN OF MACHINE MEMBERS-I**

UNIT-I: Introduction and Design of Static strength

S.No	Date	Hour	Topic	No of periods	REMARKS
1			General considerations in the design of Engineering Materials and their properties,selection	3	
2			Manufacturing consideration in design, tolerances and fits –BIS codes of steels.	3	
3			Simple stresses,combined stresses,torsional and bending stresses. impact stresses	4	
4			stress strain relation and various theories of failure factor of safety	3	
5			design for strength and rigidity preferred numbers.	3	
6			Stiffness in tension,bending, torsion and combined situations,static strength design based on fracture toughness.	4	
			TOTAL CLASSES	**18**	

UNIT-II :Design for Fatigue strength:

S.No	Date	Hour	Topic	No of periods	REMARKS
1			Stress concentration – theoretical stress concentration factor and fatigue stress concentration factor	3	
2			notch sensitivity .design for fluctuating stresses	4	
3			Endurance limit and estimation of endurance strength	3	
4			Goodman's line, Soderberg's line and modified Goodman's line.	6	
			TOTAL CLASSES	**16**	

UNIT-III : Riveted and welded and Bolted joints

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Reveted joints,Methods of failure of riveted joints.	2	
2			Strength equation and Efficiency of riveted joints, eccentrically loaded Riveted joints	6	
3			Welded joints,Design of fillet welds, axial loads	2	
4			circular fillet welds Under Bending, torsion and under eccentric loading	4	
5			Bolted joints, design of Bolts with Pre-stresses	2	
6			design of joints under eccentric loading, locking Devices and Bolts of Uniform strength.	4	
			TOTAL CLASSES	**20**	

2

3.

4

Staff S

Principal

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Abdullapurmet (M), R.R. Dist. HYD-501 505

LESSON PLAN

Staff Name : Upender R Department : MECH

Class : III B Tech Subject : DMM-I Semester : I Branch : MECH Section : A Year : 2019-20

Sl. No.	Unit No.	Date	Topics to be covered	No. of periods Required	Cumulative Periods

UNIT-IV :KEYS, COTTERS AND KNUCKLE JOINTS:

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Design of keys and stresses in keys	6	
2			Stresses in cotter joints,spigot and sockets	4	
3			Stresses in sleeve and cotter.	4	
4			stresses in jib and cotter joints- knuckle joints.	4	
			TOTAL CLASSES	18	

UNIT-V : SHAFTS and SHAFT COUPLING:

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Design of solid and hollow shafts for strength and rigidity	5	
2			design of shafts for combined bending,and axial loads, shaft sizes and BIS code.	2	
3			Use of internal and external circlips, gaskets and seals	4	
4			Rigid couplings muff, split muff and flange couplings	3	
5			Flexible couplings and modified flange coupling.	4	
			TOTAL CLASSES	18	

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Staff Sign.: H.O.D. Principal :

COURSE PLAN

Staff Name : Upendar R Department : MECH

Class : III B.Tech Subject : DMM-I Semester : I Branch : MECH Section : A Year : 2019-20

S.No.	Unit No.	Date	Topics to be covered	No. of Periods

ANNAMACHARYA INSTITUTE OF TECHNOLOGY & SCIENCES
DEPARTMENT OF MECHANICAL ENGINEERING
COURSE PLAN

B.Tech III Year I Semester
Name of the staff member :
SUBJECT:

Academic year: 2019-20
UPENDAR R
DESIGN OF MACHINE MEMBERS-I

S.NO.	UNIT NO.	UNIT NAME	NO OF PERIODS REQUIRED	REMARKS
1	I	Introduction and Design of Static strength	18	
2	II	Design for Fatigue strength	16	
3	III	Riveted and welded and Bolted joints	20	
4	IV	Keys, Cotters and knuckle Joints	18	
5	V	SHAFTS and SHAFT COUPLING	18	
		TOTAL CLASSES	90	

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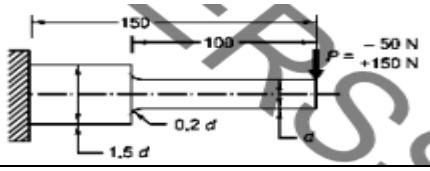
TOTAL

Assignment.1.

Design of Machine Members –I

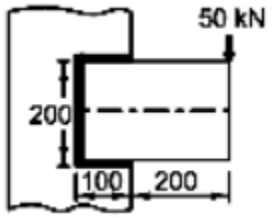
S.No	Questions
1	Derive an expression for the impact stress induced due to a falling load.
2	Write short notes on maximum shear stress theory.
3	At a critical section in a shaft, the following stresses are induced: Bending stress=60 Mpa Torsional shear stress =40 Mpa Determine the factor of safety, according to (i) maximum normal stress theory, (ii) maximum shear stress theory, (iii) maximum principal strain theory. The proportional limit in a simple tension test is found to be 300 Mpa. Take Poisson's ratio as 0.3.
4	Define a fit and a tolerance.
5	A cantilever of span 500 mm carries a vertical download load of 6 KN at free end. Assume yield value of 350 MPa and factor of safety of 3. Find the economical section for the cantilever among: i) a circular cross section of diameter 'd', ii) rectangular section of depth 'h' and width 't' with h /t = 2.
6	Find the diameter of shaft required to transmit 60 kW at 150 rpm if the maximum torque is likely to exceed the mean torque by 25% for a maximum permissible torsional shear stress of 60 N/mm^2 . Also find the angle of twist for a length of 2.5 meters. Take G = 80 GPa.
7	What are alloy steels? Discuss the effect of adding different alloying elements in steel?
8	An electric motor weighing 500N is mounted on a short cantilever beam of uniform rectangular cross section. The weight of motor acts at a distance of 300mm from the support. The depth of the section is twice the width. Determine the cross section of the beam. The allowable stress in the beam is $40N/mm^2$
9	What are the general considerations in the design of machine elements?
10	Write about types of fits?
11	Explain the design considerations for the selection of Engineering Materials and their properties?
12	Explain the concept of stiffness in tension, bending,and torsion and combined situations?
13	Write about preferred numbers?
14	Explain the manufacturing considerations in design?
15	How do you understand failure? Explain the various theories of failure?
16	Discuss in detail the factors which govern the selection of material for a machine component?
17	Explain the salient features of the maximum principal stress theory and indicate under what conditions such a theory is useful?
18	A steel shaft 35 mm in diameter and 1.2 m long held rigidly at one end has a hand wheel 500 mm in diameter keyed to the other end. The modulus of rigidity of steel is 80 GPa i) What load applied to tangent to the rim of the wheel produce a torsional shear of 60MPa? ii) How many degrees will the wheel turn when this load is applied?
19	Derive a relation for the shear stress developed in a shaft, when it is subjected to torsion.

Assignment-II

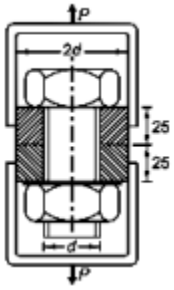
S.No	Questions	Year	Marks
1	A cantilever beam made of cold drawn steel 40C8 (S_{ut} = 600 N/mm^2 and S_{yt} = 380 N/mm^2) is shown in Figure. 1. The force P acting at the free end varies from – 50 N to +150 N. The expected reliability is 90% and the factor of safety is 2. The notch sensitivity factor at the fillet is 0.9. Determine the diameter d of the beam at the fillet cross-section using Gerber curve as failure criterion. 	2014	15
2	A bar of circular cross-section is subjected to alternating tensile forces varying from a minimum of 200 kN to a maximum of 500 kN. It is to be manufactured of a material with an ultimate tensile strength of 900 MPa and an endurance limit of 700 MPa. Determine the diameter of bar using safety factors of 3.5 related to ultimate tensile strength and 4 related to endurance limit and a stress concentration factor of 1.65 for fatigue load. Use Goodman straight line as basis for design	2016	15
3	A 25 mm diameter shaft is made of forged steel 30C8 (sut = 600 N/mm^2). There is a step in the shaft, and the theoretical stress concentration factor at the step is 2.1. The notch sensitivity factor is 0.84. Determine the Endurance limit of the shaft, if it is subjected to a reversed bending moment.	2015	5
4	A machine component is subjected to a flexural stress which fluctuates between + 300 MN/m2 and – 150 MN/m^2 . Determine the value of minimum ultimate strength according to a) Gerber relation b) Modified Goodman relation c) Soderberg relation. Take yield strength = 0.55 Ultimate strength, endurance strength = 0.5 Ultimate	2018	10
5	A stepped shaft transmits a torque varying from 800 N-m to 1200 N-m. The ratio of diameters is 1.5 and the stress concentration factor is 1.2. Determine the diameter of the shaft for infinite life for a design factor of safety 1.8. The value of sut = 600 N/mm ^{2} , and syt = 450 N/mm ^{2} .	2018	5
6	A simply supported shaft of 50 mm diameter and 0.5 m long is subjected to, at its midsection, a load that varies cyclically from 2P to 4P. Determine the value of P. Yield strength=450 MPa, Endurance limit=350 Mpa, Factor of safety=2, size correction factor=0.85 and surface correction factor =0.9.	2017	8
7	A cantilever of circular cross section is fixed at one end and subjected to completely reversed force of 10 kN at the free end. The force is perpendicular to the axis of the beam. The distance between the free and fixed end is 100 mm. The beam is made up of steel with ultimate tensile strength of 540 N/mm^2 and tensile yield strength of 320N/mm^2 . The construction of cantilever is such that there is no stress concentration. The size factor, surface finish factor and reliability factor are 0.85, 0.8, and 0.86 respectively. The operating temperature is 50^{0}C for which the temperature factor is 1.010. If the diameter of the beam is 35mm determine the life of the beam?	2016	10
8	A machine component is subjected to a flexural stress which fluctuates between + 300 MN/m^2 and – 150 MN/m^2.Determine the value of minimum ultimate strength according to (a) Gerber relation (b) Modified Goodman relation (c) Soderberg relation. Take yield strength = 0.55 Ultimate strength, endurance strength = 0.5 Ultimate strength and factor of safety = 2.	2015	10

Assignment-III

Q.1. A welded connection of steel plates is shown in Figure. 3. It is subjected to an eccentric force of 50 kN. Determine the size of the weld, if the permissible shear stress in the weld is not to exceed 70 N/mm^2 . (15)



Q.2. Two circular plates with (2d) and (d) as outer and inner diameters respectively, are clamped together by means of a bolt as shown in Figure. The bolt is made of plain carbon steel 45C8 (Syt = 380 N/mm^2 and E = 207000 N/mm^2), while the plates are made of aluminium (E = 71000 N/mm^2). The initial pre-load in the bolt is 5 kN and the external force acting on the bolted joint is 10 kN. Determine the size of the bolt, if the factor of safety is 2.5. (15)



Q.3. A cylinder head is held on the cylinder by 8 numbers of bolts. The inner diameter of the cylinder is 350 mm. The pressure inside the cylinder varies from zero to a maximum pressure of 2.5 MPa. The ultimate tensile stress and yield stress are 630 MPa and 380 MPa respectively. The bolts are tightened with initial preload of 1.5 times the steam load. A copper asbestos gasket is used to make the joint leak proof. Take factor of safety is 2.5. Neglect stress concentration factor. Find the size of the bolt. (8)

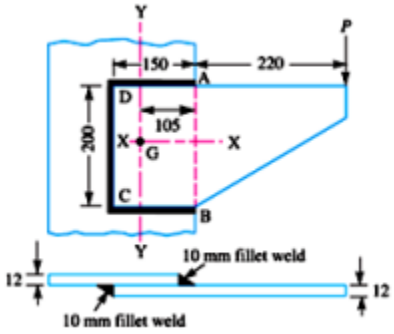
Q.4. Explain the design of bolt subjects to uniform loading. (7)

Q.5. What are bolts of uniform strength? Where are they used? Explain with a sketch. (5)

Q.6. A double – riveted double – strap butt joint is used to connect two plates, each of 12 mm thickness, by means of 16 mm diameter rivets having a pitch of 48 mm. The rivets and plates are made of steel. The permissible stresses in tension, shear, and compression are 80, 60, and 120 N/mm 2 respectively. Find the efficiency of the joint. (5)

Q.7. Design a lap joint for a mild steel flat tie-bar 200 mm × 10 mm thick, using 24 mm diameter rivets. Assume allowable stresses in tension and compression of the plate material as 112 MPa and 200 MPa respectively and shear stress of the rivets as 84 MPa. Show the disposition of the rivets for maximum joint efficiency and determine the joint efficiency. Take diameter of rivet hole as 25.5 mm for a 24 mm diameter rivet. [10]

Q.8.A braket is welded to the side of a column and carries a vertical load P, as shown in the Figure. Evaluate P so that the maximum shear stress in the 10 mm fillet welds is 80 MPa. (10)



Q.9. Discuss the methods of failure of riveted joints. (5)

Q.10. Show that the plane of maximum shear stress occurs at 450 for a parallel load on a fillet weld of equal legs. Neglect bending. Determine the allowable force P per cm of weld length, if the allowable shear stress is 95 N/mm ^{2}. (5)

Q.11. The maximum pull in the tie rods of a turnbuckle used in the roof truss is 4.5 kN. The tie rods are made of steel 40C8 (syt = 380 N/mm 2) and the factor of safety is 5. Determine the nominal diameter of the threads on the tie rod on the basis of Maximum principal stress theory. Assume dc = 0.8 d. (5)

Q.12. What is efficiency of riveted joint? How do you find it? (5)

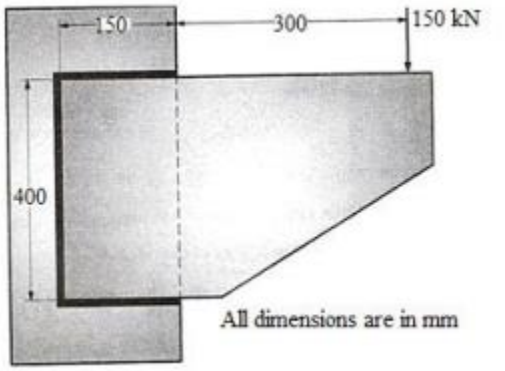
Q.13. Describe the procedure to design an eccentrically loaded welded joint. (5)

Q.14. A double riveted, chain lap joint is to be made for joining two plates of 10 mm thick. The allowable stresses are 60 MPa in tension, 80 MPa in crushing and 50 MPa in shear. Determine the rivet diameter, pitch of the rivets and row pitch. Also find the efficiency of the joint. (5)

Q.15. Explain how to design a bolt considering both initial tightening load and external force. (5)

Q.16. A flanged bearing for a horizontal shaft is fastened to a frame by means of 4 bolts, equally spaced on 160 mm pitch circle diameter. A 100 kN force acts at a distance of 50 mm from the frame. The diameter of the flange is 220 mm. Determine the size of the bolts, if the tensile stress for the bolt material is 80 MPa. (5)

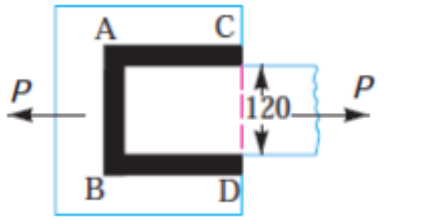
Q.17.A bracket plate carrying a load of 150 kN is to be welded to a column as shown in figure find the size of the weld, if the allowable shear stress in the weld is 120MPa. (10)



Q.18.Explain the 4 possible ways of failures in single rivet with suitable diagram for each case. (5)

Q.19. A circular bar of 50 mm diameter is welded to a steel plate by an annular fillet and is subjected to a twisting moment of 2 kNm. If the allowable shear stress in the weld material is 85 MPa, determine the size of the weld. (5)

Assigmant4,5

Q.NO	QUESTIONS
1	Write advantages and disadvantages of welded joint over riveted joints.
2	A steam engine of effective diameter 300 mm is subjected to a steam pressure of 1.5 N/mm^2.The cylinder head is connected by 8 bolts having yield point 330 MPa and endurance limit at 240 MPa. The bolts are tightened with an initial preload of 1.5 times the steam load. A soft copper gasket is used to make the joint leak-proof. Assuming a factor of safety 2, find the size of bolt required. The stiffness factor for copper gasket may be taken as 0.5.
3	What is a key? State its function with neat sketch.
4	A knuckle joint is required to withstand a tensile load of 25 kN. Design the joint if the permissible stresses are :σ_t= 56 MPa ; τ = 40 MPa and σ_c= 70 MPa
5	A shaft is supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and μ = 0.24. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley...
6	Determine the length of the weld run for a plate of size 120 mm wide and 15 mm thick to be welded to another plate by means of 1. A single transverse weld; and 2. Double parallel fillet welds when the joint is subjected to variable loads. 
7	Describe, with the help of neat sketches, the types of various shaft couplings mentioning the uses of each type.
8	Discuss the methods of failure of riveted joints.
9	A double – riveted double – strap butt joint is used to connect two plates, each of 12 mm thickness, by means of 16 mm diameter rivets having a pitch of 48 mm. The rivets and plates are made of steel. The permissible stresses in tension, shear, and compression are 80, 60, and 120 N/mm 2 respectively. Find the efficiency of the joint.
10	Design and draw a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses: Tensile stress = 60 MPa, Shear stress = 70 MPa and crushing stress = 125 MPa.
11	A solid shaft is transmitting 1 MW at 240 r.p.m. Determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20%. Take the maximum allowable shear stress as 60 MPa.
12	Describe the procedure to design an eccentrically loaded welded joint.
13	Design and make a neat dimensioned sketch of a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa.

Code No: 115DV **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year I Semester Examinations, March - 2017

DESIGN OF MACHINE MEMBERS – I

(Common to ME, AME)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

(25 Marks)

1.a)	Define factor of safety.	[2]
b)	Explain the methods to reduce stress concentration in machine members.	[3]
c)	What is row pitch and margin of a riveted joint?	[2]
d)	What do you understand by bolt of uniform strength?	[3]
e)	Explain the purpose of a gib.	[2]
f)	How is a sunk key designed?	[3]
g)	When do you consider column factor in design of shafts.	[2]
h)	How is a flange coupling modified to make it flexible coupling.	[3]
i)	What is a torsion spring?	[2]
j)	Explain surging in springs.	[3]

PART - B

(50 Marks)

2.a) What are theories of failure. Explain any two theories of elastic failure for bi-axial loading system with the help of equations.

b) A solid circular shaft, 20 mm in diameter, is subjected to torsional shear stress, which varies from 0 to 35 N/mm^2 and at the same time, is subjected to an axial stress that varies from -15 to +30 N/mm^2. The frequency of variation of these stresses is equal to the shaft speed. The shaft is made of steel FeE 400(S_{ut}=540 N/mm^2 and S_{yt}=400 N/mm^2 and the corrected endurance limit of the shaft is 200 N/mm^2. Determine the factor of safety. [5+5]

OR

3.a) What are the general considerations in designing machine members. Discuss in detail.

b) Explain about preferred numbers.

c) A simply supported shaft of 50 mm diameter and 0.5 m long is subjected to, at its mid-section, a load that varies cyclically from 2P to 4P. Determine the value of P. Yield strength=450 MPa, Endurance limit=350 Mpa, Factor of safety=2, size correction factor=0.85 and surface correction factor =0.9. [3+3+4]

4.a) Describe the procedure to design an eccentrically loaded welded joint.

b) A double riveted, chain lap joint is to be made for joining two plates of 10 mm thick. The allowable stresses are 60 MPa in tension, 80 MPa in crushing and 50 MPa in shear. Determine the rivet diameter, pitch of the rivets and row pitch. Also find the efficiency of the joint. [5+5]

OR

5.a) Explain how to design a bolt considering both initial tightening load and external force.

b) A flanged bearing for a horizontal shaft is fastened to a frame by means of 4 bolts, equally spaced on 160 mm pitch circle diameter. A 100 kN force acts at a distance of 50 mm from the frame. The diameter of the flange is 220 mm. Determine the size of the bolts, if the tensile stress for the bolt material is 80 MPa. [5+5]

6. Design a knuckle joint to connect two circular rods subjected to an axial tensile force of 50 kN. The rods are co-axial and a small amount of angular movement between their axes is permissible. Assume permissible stresses as: f_t = 80 N/mm^2; f_s = 40 N/mm^2; f_c = 80 N/mm^2. [10]

OR

7.a) Mention different types of cotter joints. Where are they used?

b) Design a socket and spigot type cotter joint to resist a load of 25 kN. Assume safe stresses as: σ_t=50 MPa; τ_{all} =40 MPa; σ_c=65 MPa. [5+5]

8.a) Write how a shaft is designed on the basis of rigidity.

b) A steel shaft 1.25 m long between bearings carries 1250 N pulley at its mid point. The pulley is keyed to the shaft and receives 20 kW at 200 rpm. The belt drive is horizontal and the ratio of the belt tensions is 3:1. The diameter of the pulley is 600 mm. Compute the shaft diameter. [5+5]

OR

9. Two 40 mm diameter shafts running at 500 rpm and transmitting a torque of 1200 Nm are connected by a rigid unprotected type of flange coupling. The flanges are fitted with six bolts. Permissible stresses are 35 MPa in shear and 45 MPa in crushing. Design the coupling with a neat sketch. [10]

10.a) Why Wahl's factor is to be considered in the design of helical compression or tension springs.

b) A spring loaded safety valve for a boiler is required to blow-off at a pressure of 1.2 N/mm^2. The diameter of the valve is 55 mm. Design a suitable compression spring for the safety valve, assuming spring index to be 6 and an initial compression 25 mm. The maximum lift of the valve is 15 mm. The shear stress in the material is to be limited to 450 MPa. Take G= 0.84×10^5 MPa. [5+5]

OR

11.a) Write the design procedure of helical compression springs under fatigue loading.

b) A bumper, consisting of two helical springs of circular section, brings to rest, a railway wagon of mass 1500 kg moving at 1.2 m/s. While doing so, the springs are compressed by 150 mm. The mean diameter of the coils is 6 times the wire diameter and permissible shear stress is 400 MPa. Design the springs. Take G= 0.84×10^5 MPa. [5+5]

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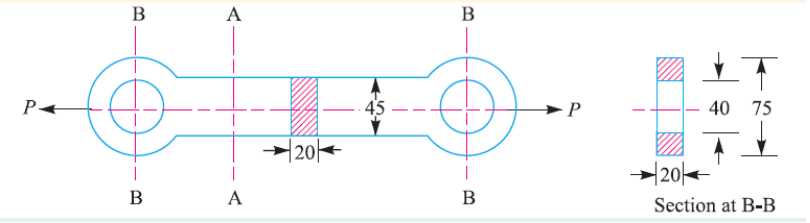
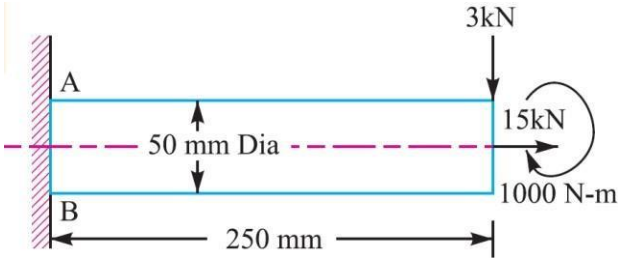
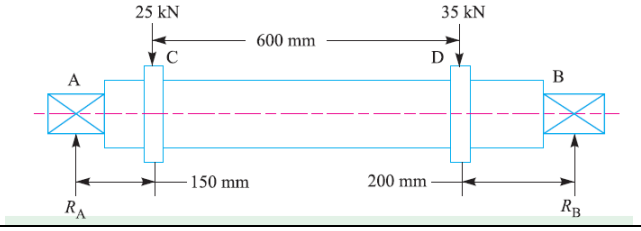
QUESTION BANK (DESCRIPTIVE)

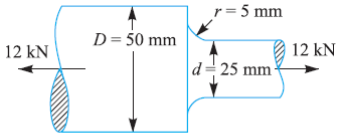
Subject with Code: DMM - I
Course & Branch: B.Tech -ME
Year &Sem: III-B.Tech& I-Sem.
Regulation: R16

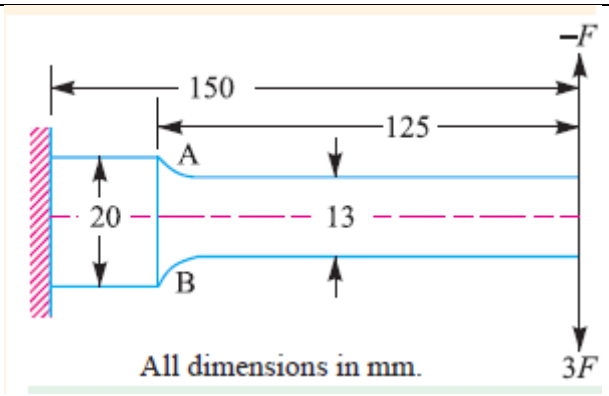
UNIT –I
INTRODUCTION & STRESS IN MACHINE MEMBERS AND DESIGN FOR STATIC STRENGTH

1	How do you classify materials for engineering use?
2	Draw the stress–strain diagram for mild steel. Explain.
3	How do you classify the machine design? Explain
4	Explain the general design procedure while designing a machine element
5	What are the general design consideration should be followed while designing aMachine element?
6	What are the manufacturing consideration should be followed while designing amachine element?
7	What do you mean by preferred numbers and explain the applications?
8	What is meant by factor of safety? Explain how it can be used in designapplications.
9	A cast iron link, as shown in Fig., is required to transmit a steady tensile load of 45 kN. Find the tensile stress induced in the link material at sections A-A and B-B. 
10	A hydraulic press exerts a total load of 3.5 MN. This load is carried by two steel rods, supporting the upper head of the press. If the safe stress is 85 MPa and E = 210KN/mm^2, find : 1. diameter of the rods, and 2. extension in each rod in a length of 2.5m.
11	A shaft, as shown in Fig. is subjected to a bending load of 3 kN, pure torque of 1000 N-m and an axial pulling force of 15 kN. Calculate the stresses at A and B. 
12	Derive an expression for the impact stress induced due to a falling load.
13	An unknown weight falls through 10 mm on a collar rigidly attached to the lowerend of a vertical bar 3 m long and 600 mm^2 in section. If the maximum instantaneous extension is known to be 2 mm, what is the corresponding stress and the value ofunknown weight? Take E = 200 kN/mm^2.
14	Write the bending stress relation and draw the diagram.

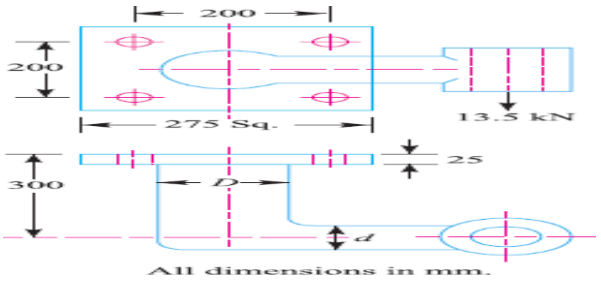
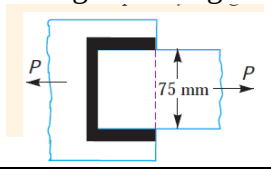
15	A pump lever rocking shaft is shown in Fig. The pump lever exerts forces of 25 kN and 35 kN concentrated at 150 mm and 200 mm from the left and right hand bearing respectively. Find the diameter of the central portion of the shaft, if the stress is not to exceed 100 MPa 
16	The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of bolt required according to 1. Maximum principal stress theory; 2.Maximum shear stress theory; 3.Maximum principal strain theory; 4.Maximum strain energy theory; and 5.Maximum distortion energy theory.
17	A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000N-m and a torque T. If the yield point of the steel in tension is 200 MPa, find themaximum value of this torque without causing yielding of the shaft according to 1. The maximum principal stress; 2. The maximum shear stress; and 3.The maximumdistortion strain energy theory of yielding.
18	Derive an expression for the impact stress induced due to a falling load.
19	Write short notes on maximum shear stress theory.
20	At a critical section in a shaft, the following stresses are induced: Bending stress=60 Mpa Torsional shear stress =40 Mpa Determine the factor of safety, according to (i) maximum normal stress theory, (ii) maximum shear stress theory, (iii) maximum principal strain theory. The proportional limit in a simple tension test is found to be 300 Mpa. Take Poisson's ratio as 0.3.
21	Define a fit and a tolerance.
22	A cantilever of span 500 mm carries a vertical download load of 6 KN at free end. Assume yield value of 350 MPa and factor of safety of 3. Find the economical section for the cantilever among: i) a circular cross section of diameter 'd', ii) rectangular section of depth 'h' and width 't' with h /t = 2.
23	Find the diameter of shaft required to transmit 60 kW at 150 rpm if the maximum torque is likely to exceed the mean torque by 25% for a maximum permissible torsional shear stress of 60 N/mm^2 . Also find the angle of twist for a length of 2.5 meters. Take G = 80 GPa.
24	What are alloy steels? Discuss the effect of adding different alloying elements in steel?
25	An electric motor weighing 500N is mounted on a short cantilever beam of uniform rectangular cross section. The weight of motor acts at a distance of 300mm from the support. The depth of the section is twice the width. Determine the cross section of the beam. The allowable stress in the beam is $40N/mm^2$
26	What are the general considerations in the design of machine elements?
27	Write about types of fits?
28	Explain the design considerations for the selection of Engineering Materials and their properties?
29	Explain the concept of stiffness in tension, bending, and torsion and combined situations?
30	Write about preferred numbers?
31	Explain the manufacturing considerations in design?
32	A steel shaft 35 mm in diameter and 1.2 m long held rigidly at one end has a hand wheel 500 mm in diameter keyed to the other end. The modulus of rigidity of steel is 80 GPa. i) What load applied to tangent to the rim of the wheel produce a torsional shear of 60MPa? ii) How many degrees will the wheel turn when this load is applied?
33	Derive a relation for the shear stress developed in a shaft, when it is subjected to torsion.

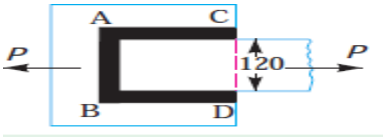
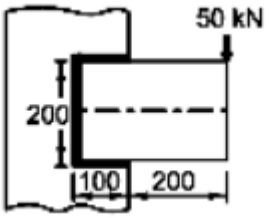
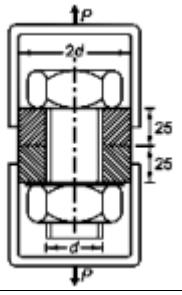
UNIT –II
DESIGN FOR FATIGUE STRENGTH

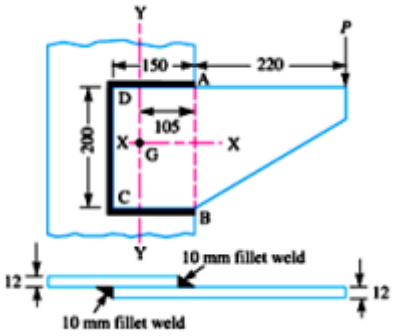
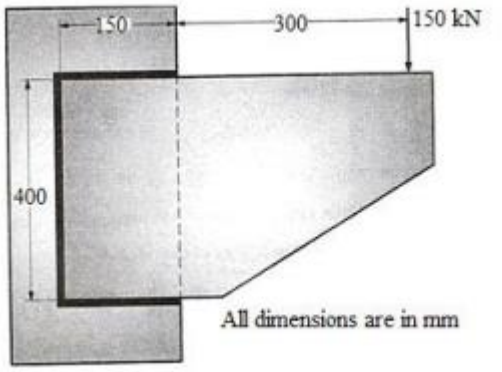
1	Explain stress concentration in detail and various methods to reduce stress concentration in machine members.
2	Define the following terms i) Theoretical Stress concentration factor ii) Fatigue Stress concentration factor iii) Endurance limit with the effect of size, load and surface factors iv) Fatigue failure
3	Discuss the factors affecting endurance limit
	Determine the diameter of a circular rod made of ductile material with a fatigue strength (complete reversal), σ_e=265 MPa and tensile yield strength of 350 MPa. The member is subjected to a varying axial load from W_{min} =-300 KN to W_{max} = 700 KN and has a stress concentration factor is 1.8. Use factor of safety as 2.
4	What is the notch sensitivity? And write the expression for it?
5	Find the maximum stress induced in the following case taking stress concentration into account: A stepped shaft as shown in Fig. (b) and carrying a tensile load of 12 KN  (b)
6	What are the fluctuating stress, repeated stress and reversed stress? Draw the Stress– Time sinusoidal curves.
7	Determine the diameter of a circular rod made of ductile material with a fatigue strength (complete reversal), σ_e=265 MPa and tensile yield strength of 350 MPa. The member is subjected to a varying axial load from W_{min} =-300 KN to W_{max} = 700 KN and has a stress concentration factor is 1.8. Use factor of safety as 2.
8	Define the term “stress concentration” with suitable diagram and “stress concentration factor” also.
9	N/mm^2 to 100 N/mm^2. The corrected endurance limit of the machine component is 270 N/mm^2. The ultimate stress and yield point stress of the material are 600 and 400 N/mm^2 respectively. Find the factor of safety using: (i) Gerber formula. (ii) Solderberg line. (iii) Goodman line.
10	A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20 kN and a maximum value of 50 kN. Determine the diameter of bar by taking a factor of safety of 1.5, size effect of 0.85, surface finish factor of 0.9. The material properties of bar is given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa.
11	Cantilever beam made of cold drawn carbon steel of circular cross-section as shown in Fig. Is subjected to a load which varies from – F to 3 F. Determine the maximum load that this member can withstand for an indefinite life using a factor of safety as 2. The theoretical stress concentration factor is 1.42 and the notch sensitivity is 0.9. Assume the following values : Ultimate stress = 550 MPa Yield stress = 470 MPa Endurance limit = 275 MPa Size factor = 0.85 Surface finish factor= 0.89

	
12	A machine component is subjected to a flexural stress which fluctuates between + 300 MN/m^2 and – 150 MN/m^2. Determine the value of minimum ultimate strength according to 1. Gerber relation; 2. Modified Goodman relation; and 3. Soderberg relation. Take yield strength = 0.55 Ultimate strength; Endurance strength = 0.5 Ultimate strength; and Factor of safety = 2.
13	A hot rolled steel shaft is subjected to a torsional moment that varies from 330 N.m clockwise to 110 N.m counter clockwise and an applied bending moment at a critical section varies from 440N-m to-220 N-m. The shaft is of uniform cross-section and no key way is present at the critical section. Determine the required shaft diameter. The material has an ultimate strength of 550 MN/m^2 and yield strength of 410 MN/m^2.Take the endurance limit as half the ultimate strength, factor of safety of 2, size factor of 0.85 and surface finish factor of 0.62.
14	How do you understand failure? Explain the various theories of failure?
15	A transmission shaft of cold drawn steel 27Mn2 (Sut = 500 N/mm^2 and Syt = 30N/mm^2) is subjected to a fluctuating torque which varies from -100 N-m to +400 N-m. The factor of safety is 2 and the expected reliability is 10%. Neglecting the effect of stress concentration, determine the diameter of the shaft. Assume the distortion energy theory of failure.

UNIT –III
DESIGN OF RIVETED, WELDED AND BOLTED JOINTS

1	Mentioned the important terms used in screw threads with a neat sketch.
2	Describe the initial stresses in screw fasteners due to screwing up forces.
3	Explain Stress in screw fasteners due to Combined Forces?
4	Two machine parts are fastened together tightly by means of a 24 mm tap bolt. If the load tending to separate these parts is neglected, find the stress that is set up in thebolt by the initial tightening.
5	Discuss on bolts of uniform strength giving examples of practical applications of such bolts.
6	**b.**A lever loaded safety valve has a diameter of 100 mm and the blow off pressure is 1.6 N/mm^2. The fulcrum of the lever is screwed into the cast iron body of the cover. Find the diameter of the threaded part of the fulcrum if the permissible tensile stress is limited to 50 MPa and the leverage ratio is 8.
7	Derive the expression for eccentric load acting parallel to the axis of bolts
8	Fig. shows a solid forged bracket to carry a vertical load of 13.5 kN applied through the centre of hole. The square flange is secured to the flat side of a vertical stanchion through four bolts. Calculate suitable diameter D and d for the arms of the bracket, ifthe permissible stresses are 110 MPa in tension and 65 MPa in shear. Estimate also thetensile load on each top bolt and the maximum shearing force on each bolt. 
9	Write advantages and disadvantages of welded joint over riveted joints.
10	Discuss the standard location of elements of a welding symbol.
11	What are the advantages of preloading bolted joints?
12	A steam engine of effective diameter 300 mm is subjected to a steam pressure of 1.5 N/mm^2. The cylinder head is connected by 8 bolts having yield point 330 MPa and endurance limit at 240 MPa. The bolts are tightened with an initial preload of 1.5 times the steam load. A soft copper gasket is used to make the joint leak-proof. Assuming a factor of safety 2, find the size of bolt required. The stiffness factor for copper gasket may be taken as 0.5.
13	What is an eccentric loaded welded joint? Discuss the procedure for designing sucha joint.
14	A plate 100 mm wide and 10 mm thick is to be welded to another plate by means ofdouble parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of weld if the permissible shear stress in theweld does not exceed 55 MPa.
15	A plate 75 mm wide and 12.5 mm thick is joined with another plate by a single transverse weld and a double parallel fillet weld as shown in Fig. The maximum tensile and shear stresses are 70 MPa and 56 MPa respectively. Find the length ofeach parallel fillet weld, if the joint is subjected to both static and fatigue loading. 
16	Determine the length of the weld run for a plate of size 120 mm wide and 15 mm thick to be welded to another plate by means of

	1. A single transverse weld; and 2. Double parallel fillet welds when the joint is subjected to variable loads. 
17	A welded connection of steel plates is shown in Figure. 3. It is subjected to an eccentric force of 50 kN. Determine the size of the weld, if the permissible shear stress in the weld is not to exceed 70 N/mm^2 . 
18	Two circular plates with (2d) and (d) as outer and inner diameters respectively, are clamped together by means of a bolt as shown in Figure. The bolt is made of plain carbon steel 45C8 (Syt = 380 N/mm^2 and E = 207000 N/mm^2), while the plates are made of aluminium (E = 71000 N/mm^2). The initial pre-load in the bolt is 5 kN and the external force acting on the bolted joint is 10 kN. Determine the size of the bolt, if the factor of safety is 2.5. 
19	A cylinder head is held on the cylinder by 8 numbers of bolts. The inner diameter of the cylinder is 350 mm. The pressure inside the cylinder varies from zero to a maximum pressure of 2.5 MPa. The ultimate tensile stress and yield stress are 630 MPa and 380 MPa respectively. The bolts are tightened with initial preload of 1.5 times the steam load. A copper asbestos gasket is used to make the joint leak proof. Take factor of safety is 2.5. Neglect stress concentration factor. Find the size of the bolt
20	Explain the design of bolt subjects to uniform loading.
21	What are bolts of uniform strength? Where are they used? Explain with a sketch.
22	A double – riveted double – strap butt joint is used to connect two plates, each of 12 mm thickness, by means of 16 mm diameter rivets having a pitch of 48 mm. The rivets and plates are made of steel. The permissible stresses in tension, shear, and compression are 80, 60, and 120 N/mm^2 respectively. Find the efficiency of the joint.
23	Design a lap joint for a mild steel flat tie-bar 200 mm × 10 mm thick, using 24 mm diameter rivets. Assume allowable stresses in tension and compression of the plate material as 112 MPa and 200 MPa respectively and shear stress of the rivets as 84 MPa. Show the disposition of the rivets for maximum joint efficiency and determine the joint efficiency. Take diameter of rivet hole as 25.5 mm for a 24 mm diameter rivet.

24	A braket is welded to the side of a column and carries a vertical load P, as shown in the Figure. Evaluate P so that the maximum shear stress in the 10 mm fillet welds is 80 MPa. 
25	Discuss the methods of failure of riveted joints.
26	Show that the plane of maximum shear stress occurs at 450 for a parallel load on a fillet weld of equal legs. Neglect bending. Determine the allowable force P per cm of weld length, if the allowable shear stress is 95 N/mm ^{2}.
27	The maximum pull in the tie rods of a turnbuckle used in the roof truss is 4.5 kN. The tie rods are made of steel 40C8 (syt = 380 N/mm 2) and the factor of safety is 5. Determine the nominal diameter of the threads on the tie rod on the basis of Maximum principal stress theory. Assume dc = 0.8 d.
28	What is efficiency of riveted joint? How do you find it?
29	Describe the procedure to design an eccentrically loaded welded joint.
30	A double riveted, chain lap joint is to be made for joining two plates of 10 mm thick. The allowable stresses are 60 MPa in tension, 80 MPa in crushing and 50 MPa in shear. Determine the rivet diameter, pitch of the rivets and row pitch. Also find the efficiency of the joint.
31	Explain how to design a bolt considering both initial tightening load and external force.
32	A flanged bearing for a horizontal shaft is fastened to a frame by means of 4 bolts, equally spaced on 160 mm pitch circle diameter. A 100 kN force acts at a distance of 50 mm from the frame. The diameter of the flange is 220 mm. Determine the size of the bolts, if the tensile stress for the bolt material is 80 MPa.
33	A bracket plate carrying a load of 150 kN is to be welded to a column as shown in figure find the size of the weld, if the allowable shear stress in the weld is 120MPa. 
34	Explain the 4 possible ways of failures in single rivet with suitable diagram for each case.
35	A circular bar of 50 mm diameter is welded to a steel plate by an annular fillet and is subjected to a twisting moment of 2 kNm. If the allowable shear stress in the weld material is 85 MPa, determine the size of the weld.

UNIT –IV
DESIGN OF MECHANICAL KEYS, COTTERS AND KNUCKLE JOINTS

1	Design and draw a cotter joint to support a load varying from 30 kN in compression to 30 kN in tension. The material used is carbon steel for which the following allowable stresses may be used. The load is applied statically. Tensile stress = compressive stress = 50 MPa ; shear stress = 35 MPa and crushing stress = 90 MPa.
2	Design a gib and cottor joint to carry a maximum load of 35 kN. Assuming that the gib, cotter and rod are of same material and have the following allowable stresses: σt = 20 MPa ; τ = 15 MPa ; and σc = 50 MPa.
3	What are the applications of a cottered joint?
	A knuckle joint is required to withstand a tensile load of 25 kN. Design the joint if the permissible stresses are :σt= 56 MPa ; τ = 40 MPa and σc= 70 MPa.
4	Design and draw a spigot and socket cotter joint to support a load varying from 30 kN in compression to 30 kN in tension. The material used is carbon steel for which the following allowable stresses may be used. The load is applied statically.Tensile stress = compressive stress = 50 MPa; shear stress = 35 MPa and crushing stress = 90 MPa.
5	Design a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses: Tensile stress = 60 MPa; shear stress = 70 MPa; and compressive stress = 125 MPa.
6	Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m. and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shear stressfor cast iron is 14 MPa.
7	What is a key? State its function with neat sketch.
8	Design the rectangular key for a shaft of 50 mm diameter. The shearing and crushing stresses for the key material are 42 MPa and 70 MPa.
9	How are the keys classified? Draw neat sketches of different types of keys and state their applications.
10	What is the effect of keyway cut into the shaft?
11	A 45 mm diameter shaft is made of steel with yield strength of 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2.
12	Distinguish between cotter joint and knuckle joint.
13	What is the effect of keyway cut into the shaft?
14	Design and draw a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses: Tensile stress = 60 MPa, Shear stress = 70 MPa and crushing stress = 125 MPa
15	Design and draw a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing.
16	Square key is stronger against crushing than rectangular key justify the statement.
17	A 16×10mm^2 cross section parallel key is to be used to transmit 60 kW power at 1440 rpm from a shaft of 45mm diameter. The key is made of plain carbon steel with yield strength of 300N/mm^2. If the required safety margin is 3, determine the key length
18	List out the procedure for designing a knuckle joint stating all the empirical relations

	involved in it with suitable diagram.
19	Kennedy keys are used to transmit 30 kW power at 500 rpm from 40mm diameter shaft to the hub. The keys are made of steel 55C8 with yield strength of 400N/mm2 and ultimate tensile strength of 700N/mm^2. If the factor of safety required is 3 and overload factor is 1.5 design the keys. 20With neat diagram explain the design procedure involved in designing a cotter joint.
20	Explain the purpose of a gib.
21	How is a sunk key designed?
22	Design a knuckle joint to connect two circular rods subjected to an axial tensile force of 50 kN. The rods are co-axial and a small amount of angular movement between their axes is permissible. Assume permissible stresses as: ft = 80 N/mm^2 ; fs = 40 N/mm2 ; fc = 80 N/mm^2 .
23	Mention different types of cotter joints. Where are they used?
24	Design a socket and spigot type cotter joint to resist a load of 25 kN. Assume safe stresses as: σt=50 MPa; τ =40 MPa; σc=65 MPa.
25	Where do you use a Knuckle joint? Give practical examples
26	Sketch the following types of keys: Taper sunk key, Feather key, Woodruff key.
27	The maximum pull in the tie rods of a turnbuckle used in the roof truss is 4.5 kN. The tie rods are made of steel 40C8 (sy_t=380 N/mm^2), and the factor of safety is 5. Determine the nominal diameter of the threads on the tie rod on the basis of Maximum principal stress theory. Assume dc = 0.8 d. b) What is efficiency of riveted joint? How do you find it?
28	What are the basic functions of keys? What are the factors on which the selection of the type of key for a given application depends?
29	Two rods are connected by means of a knuckle joint. The axial force acting on the rods is 25 kN. The rods and pin are made of plain carbon steel 45C8 (sy_t=380 N/mm^2), and the factor of safety is 2.5. The yield strength in shear is 57.7% of the yield strength in tension. Calculate the diameter of the rods and the diameter of the pin.
30	What are the applications of a cotter joint? Explain.
31	A 45 mm diameter shaft is made of steel with a yield strength of 400 MPa. A parallel key of size 14 mm width and 9 mm thickness made of steel with yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2.
32	Why is a cotter joint provided with a taper? And why is the taper provided only on one side?
33	What is Kennedy key? What are its advantages and disadvantages over flat key
34	Two rod ends of a pump are joined by means of a cotter and spigot and socket at the ends. Design the joint for an axial load of 100 kN which alternately changes from tensile to compressive. The allowable stresses for the material are 50 MPa in tension, 40 MPa in shear, and 100 MPa in crushing.
35	What is a cotter joint? Why is cotter provided with a taper, and why is the taper provided only on one side?
36	Why is taper provided on a sunk key? And why is the taper provided only on one side
37	It is required to design a square key for fixing a pulley on the shaft, which is 50 mm in diameter. The pulley transmits 10 kW power at 200 rpm to the shaft. The key is made of steel 45C8 (sy_t =sy_c=380N/m^2) and the factor of safety is 3. Determine the dimensions of the key.
38	Why gibs are used in a cotter joint? Explain, with a sketch the use of double gib.

39	A rectangular sunk key 14 mm wide, 10 mm thick and 75 mm long is required to transmit 1200 N-m torque from a 50 mm diameter solid shaft. Determine whether the length is sufficient or not, if the permissible shear stress and crushing stress are limited to 56 MPa and 168 MPa respectively.

UNIT –V

DESIGN OF SHAFTS & DESIGN OF COUPLINGS

1	What type of stresses is induced in shafts?
2	A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 70 MPa and a ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft.
3	A shaft is supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and $\mu = 0.24$. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley.
4	A steel solid shaft transmitting 15 kW at 200 r.p.m. is supported on two bearings 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5 mm module is located 100 mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5 mm module is located 150 mm to the right of the left hand bearing and receives power in a vertical direction from below. Using an allowable stress of 54 MPa in shear, determine the diameter of the shaft.
5	How the shaft is designed when it is subjected to twisting moment only?
6	A shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 meters. It carries two pulleys each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe valu of stress, determine the diameter of the shaft.
7	A solid shaft is transmitting 1 MW at 240 r.p.m. Determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20%. Take the maximum allowable shear stress as 60 MPa.
8	A steel spindle transmits 4 kW at 800 r.p.m. The angular deflection should not exceed 0.25° per metre of the spindle. If the modulus of rigidity for the material of the spindle is 84 GPa, find the diameter of the spindle and the shear stress induced in the spindle.
9	Discuss the function of a coupling. Give at least three practical applications.
10	Design and make a neat dimensioned sketch of a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa.
11	Describe, with the help of neat sketches, the types of various shaft couplings mentioning the uses of each type.
12	Design and draw a clamp coupling to transmit 30 kW at 100 r.p.m. The allowable shear stress for the shaft and key is 40 MPa and the number of bolts connecting the two halves are six. The permissible tensile stress for the bolts is 70 MPa. The coefficient of friction between the muff and the shaft surface may be taken as 0.3.
13	Design a cast iron protective type flange coupling to transmit 15 kW at 900 r.p.m. from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stresses may be used: Shear stress for shaft, bolt and key material = 40 MPa Crushing stress for bolt and key = 80 MPa Shear stress for cast iron = 8 MPa Draw a neat sketch of the coupling.

14	Design and draw a cast iron flange coupling for a mild steel shaft transmitting 90 kW at 250 r.p.m. The allowable shear stress in the shaft is 40 MPa and the angle of twist is not to exceed 1° in a length of 20 diameters. The allowable shear stress in the coupling bolts is 30 MPa.
15	Design a bushed-pin type of flexible coupling to connect a pump shaft to a motor shaft transmitting 32 kW at 960 r.p.m. The overall torque is 20 percent more than mean torque.The material properties are as follows : 1. The allowable shear and crushing stress for shaft and key material is 40 MPa and 80 MPa respectively. 2. The allowable shear stress for cast iron is 15 MPa. 3. The allowable bearing pressure for rubber bush is 0.8 N/mm^2. 4. The material of the pin is same as that of shaft and key. Draw neat sketch of the coupling

R13

Code No: 115DV

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year I Semester Examinations, November - 2015

DESIGN OF MACHINE MEMBERS – I
(Common to ME, AME)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A (25 Marks)

1.a) What are the factors to be considered for the selection of materials for the design of machine elements? [2]
b) Illustrate how the stress concentration in a component can be reduced. [3]
c) What is an economical joint and where does it find applications? [2]
d) Sketch and discuss the various types of welded joints used in pressure vessels. [3]
e) Distinguish between cotter joint and knuckle joint. [2]
f) What is the effect of keyway cut into the shaft? [3]
g) What type of stresses are induced in shafts? [2]
h) What are flexible couplings and what are their applications? [3]
i) Classify springs according to their shapes. [2]
j) What is nipping in a leaf spring? Discuss its role. [3]

PART - B (50 Marks)
(Assume suitable data if necessary)

2. A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000 Nm and a torque T. If the yield point of the steel in tension is 200 MPa, find the maximum value of this torque without causing yielding of the shaft according to (a) the maximum principal stress (b) the maximum shear stress and (c) the maximum distortion strain energy theory of yielding. [10]

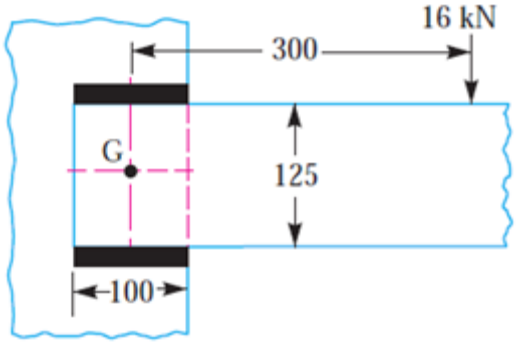
OR

3. A machine component is subjected to a flexural stress which fluctuates between + 300 MN/m^2 and – 150 MN/m^2. Determine the value of minimum ultimate strength according to (a) Gerber relation (b) Modified Goodman relation (c) Soderberg relation. Take yield strength = 0.55 Ultimate strength, endurance strength = 0.5 Ultimate strength and factor of safety = 2. [10]

4. Design the longitudinal joint for a 1.25 m diameter steam boiler to carry a steam pressure of 2.5 N/mm^2. The ultimate strength of the boiler plate may be assumed as 420 MPa, crushing strength as 650 MPa and shear strength as 300 MPa. Take the joint efficiency as 80%. Sketch the joint with all dimensions. Adopt the suitable factor of safety. [10]

OR

5. A 125 × 95 × 10 mm angle is welded to a frame by two 10 mm fillet welds, as shown in Figure. A load of 16 kN is applied normal to the gravity axis at a distance of 300 mm from the centre of gravity of weld. Find the maximum shear stress in the welds, assuming each weld to be 100 mm long and parallel to the axis of the angle. [10]



All dimensions in mm.

6. Design and draw a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses: Tensile stress = 60 MPa, Shear stress = 70 MPa and crushing stress = 125 MPa. [10]

OR

7. Design and draw a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing. [10]

8. A steel solid shaft transmitting 15 kW at 200 rpm is supported on two bearings 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5 mm module is located 100 mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5 mm module is located 150 mm to the right of the left hand bearing and receives power in a vertical direction from below. Using an allowable stress of 54 MPa in shear, determine the diameter of the shaft. [10]

OR

9. Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 rpm and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. The maximum torque is 25% greater than the full load torque. The shear stress for cast iron is 14 MPa. [10]

10. Design a helical spring for a spring loaded safety valve for the following conditions:
Diameter of the valve seat = 65 mm
Operating pressure = 0.7 N/mm^2
Maximum pressure when the valve blows off freely = 0.75 N/mm^2
Maximum lift of the valve when the pressure rises from 0.7 to 0.75 N/mm^2 is 3.5 mm
Maximum allowable stress = 550 MPa
Modulus of rigidity = 84 kN/mm^2
Spring index = 6
Draw a neat sketch of the free spring showing the main dimensions. [10]

OR

11. A helical spring *B* is placed inside the coils of a second helical spring *A*, having the same number of coils and free length. The springs are made of the same material. The composite spring is compressed by an axial load of 2300 N which is shared between them. The mean diameters of the springs *A* and *B* are 100 mm and 70 mm respectively and wire diameters are 13 mm and 8 mm respectively. Find the load taken and the maximum stress in each spring. [10]

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Code No: 115DV **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year I Semester Examinations, November/December - 2016
DESIGN OF MACHINE MEMBERS – I
(Common to ME, AME)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

(25 Marks)

1.a) List any four factors that govern selection of materials while designing a machine component. [2]
b) Define stress concentration along with its causes. Write any one method to reduce stress concentration. [3]
c) What is bolts of uniform strength? [2]
d) What are the reasons of replacing the riveted joints by welded joints in modern equipment? [3]
e) Define the term throat area of the weld. [2]
f) Square key is stronger against crushing than rectangular key justify the statement. [3]
g) With suitable example state when flexible coupling is preferred over the rigid coupling. [2]
h) Define BIS code? State its application in machine design with suitable example. [3]
i) If a single spring is cut into 2 equal pieces what will be the stiffness of each individual spring after cutting. [2]
j) What is nipping? [3]

PART - B

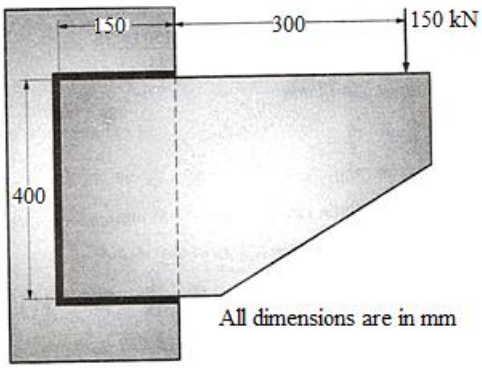
(50 Marks)

2.a) Explain the following theories of failure.
i) Rankine's Theory
ii) Maximum Strain Energy Theory
iii) Saint Venant's Theory.
b) With neat sketch explain how the Sodenberg and Goodman lines differ from each other. [6+4]

OR

3. A cantilever of circular cross section is fixed at one end and subjected to completely reversed force of 10 kN at the free end. The force is perpendicular to the axis of the beam. The distance between the free and fixed end is 100 mm. The beam is made up of steel with ultimate tensile strength of 540 N/mm^2 and tensile yield strength of $320N/mm^2$. The construction of cantilever is such that there is no stress concentration. The size factor, surface finish factor and reliability factor are 0.85, 0.8, and 0.86 respectively. The operating temperature is 50 ^0C for which the temperature factor is 1.010. If the diameter of the beam is 35mm determine the life of the beam? [10]

4. A bracket plate carrying a load of 150 kN is to be welded to a column as shown in figure find the size of the weld, if the allowable shear stress in the weld is 120MPa. [10]



OR

5.a) Explain the 4 possible ways of failures in single rivet with suitable diagram for each case.

b) A circular bar of 50 mm diameter is welded to a steel plate by an annular fillet and is subjected to a twisting moment of 2 kNm. If the allowable shear stress in the weld material is 85 MPa, determine the size of the weld. [5+5]

6.a) A $16\times10mm^2$ cross section parallel key is to be used to transmit 60 kW power at 1440 rpm from a shaft of 45mm diameter. The key is made of plain carbon steel with yield strength of $300N/mm^2$. If the required safety margin is 3, determine the key length.

b) List out the procedure for designing a knuckle joint stating all the empirical relations involved in it with suitable diagram. [6+4]

OR

7.a) Kennedy keys are used to transmit 30 kW power at 500 rpm from 40mm diameter shaft to the hub. The keys are made of steel 55C8 with yield strength of $400N/mm^2$ and ultimate tensile strength of $700N/mm^2$. If the factor of safety required is 3 and overload factor is 1.5 design the keys.

b) With neat diagram explain the design procedure involved in designing a cotter joint. [6+4]

8. A shaft supported between two bearings 400 mm apart carries an overhanging bevel gear at one end at a distance of 150 mm from the nearest bearing. The pitch circle diameter of bevel gear is 200mm. the tangential, radial and axial forces acting on the bevel gear are 28kN, 9.8kN and 2.9kN respectively. The shaft speed is 600 rpm .the ultimate and yield strengths of shaft material are 280 $N/mm^2$and 135 N/mm^2 respectively. The combined shock and fatigue factors in bending and torsion are 1.5 and 1.0 respectively. Determine the shaft diameter also calculate the power transmitted by shaft. [10]

OR

9. A bushed –pin type flexible flange coupling is used to transmit 30kW power at 1440 rpm from an electric motor to a machine. If the peak torque is 20% more than the average torque, design the coupling. Assume following permissible stresses for the components of the coupling. Take permissible bearing pressure as 1N/mm^2. [10]

Type of stress N/mm^2	C.I FLANGE	PLAIN CARBON STEEL (shaft and key)	ALLOY STEEL (pin)
Allowable tensile stress	20	80	250
Allowable compressive stress	60	80	250
Allowable shear stress	15	35	125

10.a) Write a note on short peening in springs.

b) A semi elliptic leaf spring used for an automobile suspension consists of 3 extra full length leaves and 15 graduated leaves including the master leaf. The center to center distance between two eyes of the spring is 1 meter. The maximum force that can act on the spring is 75kN .the ratio of width to thickness for each leaf is 9:1. The leaves are pre stressed in such a way that when the force is maximum the stress induced in all leaves are 450 N/mm^2. If modulus of elasticity is 2.07×10^5N/mm^2. Determine

i) The cross section of the leaves

ii) The initial nip

iii) The initial preload required to close the gap between extra full lengths and graduated leaves. [3+7]

OR

11.a) Explain the surging of leaf springs.

b) A composite compression spring has two closed coil helical springs. The outer spring is 15 mm longer than the inner spring .The outer spring has 10 coils of mean diameter 40mm and wire diameter 5 mm. The inner spring has 8 coils of mean diameter 30 mm and wire diameter 4 mm. when the spring is subjected to an axial load of 400 N Find;

i) Compression of each spring

ii) Load shared by each spring

iii) Shear stress induced in each spring.

Modulus of rigidity may be taken as 84 kN/mm^2. [3+7]

---ooOoo---

Code No: 125DV **R15**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year I Semester Examinations, May - 2018
DESIGN OF MACHINE MEMBERS - I
(Common to AME, ME)

Time: 3 hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

Illustrate your answers with NEAT sketches wherever necessary.

PART - A

(25 Marks)

1.a) Define 'Endurance limit'. [2]
b) What are the advantages of hole – basis system over shaft – basis system? [3]
c) What is 'caulking'? What is its objective? [2]
d) What is the cause of residual stresses in welded joints? How are they relieved? [3]
e) Where do you use a Knuckle joint? Give practical examples. [2]
f) Sketch the following types of keys**:** Taper sunk key, Feather key, Woodruff key. [3]
g) Define equivalent torsional moment and equivalent bending moment for a shaft. [2]
h) Give at least three practical applications of Couplings. [3]
i) What is helical torsion spring? How does it differ from helical compression spring? [2]
j) What is pulsating shear stress? Why are springs subjected to pulsating shear stress? [3]

PART - B

(50 Marks)

2.a) What is 'Preferred numbers or Preferred series'? What are its advantages?
b) The stresses at a point in a body are s_x = 90 N/mm^2, s_y = 20 N/mm^2, and s_{xy} = 80 N/mm^2. The material tests s_{yp} = 280 N/mm^2. Find the factor of safety according to the**:**
i) Maximum principal stress theory of failure,
ii) Maximum shear stress theory of failure
iii) Maximum strain energy theory of failure. [5+5]

OR

3.a) Explain the effects of Stress concentration in Fatigue loading.
b) A stepped shaft transmits a torque varying from 800 N-m to 1200 N-m. The ratio of diameters is 1.5 and the stress concentration factor is 1.2. Determine the diameter of the shaft for infinite life for a design factor of safety 1.8. The value of s_{ut} = 600 N/mm^2, and s_{yt} = 450 N/mm^2. [5+5]

4.a) Discuss the methods of failure of riveted joints.
b) Show that the plane of maximum shear stress occurs at 45^0 for a parallel load on a fillet weld of equal legs. Neglect bending. Determine the allowable force P per cm of weld length, if the allowable shear stress is 95 N/mm^2. [5+5]

OR

5.a) The maximum pull in the tie rods of a turnbuckle used in the roof truss is 4.5 kN. The tie rods are made of steel 40C8 (s_{yt} = 380 N/mm^2) and the factor of safety is 5. Determine the nominal diameter of the threads on the tie rod on the basis of Maximum principal stress theory. Assume $d_c = 0.8\,d$.

b) What is efficiency of riveted joint? How do you find it? [5+5]

6.a) What are the basic functions of keys? What are the factors on which the selection of the type of key for a given application depends?

b) Two rods are connected by means of a knuckle joint. The axial force acting on the rods is 25 kN. The rods and pin are made of plain carbon steel 45C8 (s_{yt} = 380 N/mm^2), and the factor of safety is 2.5. The yield strength in shear is 57.7% of the yield strength in tension. Calculate the diameter of the rods and the diameter of the pin. [5+5]

OR

7.a) What are the applications of a cotter joint? Explain.

b) A 45 mm diameter shaft is made of steel with a yield strength of 400 MPa. A parallel key of size 14 mm width and 9 mm thickness made of steel with a yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2. [5+5]

8.a) Distinguish between Shaft, Axle and Spindle.

b) A sleeve-coupling is used on a shaft of 40 mm diameter, delivering a torque of 50 N – m. Calculate the diameter of the pin required to hold the coupling, if the design stress for the pin material in shear is 100 MPa. [5+5]

OR

9.a) Explain the design procedure for Muff coupling.

b) A hollow circular shaft of outer and inner diameters d_o and d_i respectively is subjected to a torsional moment of M_t over a length l. The permissible angle of twist is θ degrees. Prove that the shaft diameter is given by: $d_o = \left[\frac{584 M_t l}{G\theta(1 - C^4)}\right]$, where $C = \left(\frac{d_i}{d_o}\right)$. [5+5]

10.a) How do you determine the natural frequency of helical springs?

b) A helical compression spring is subjected to an initial pre-load of 50 N, and the maximum force during the load cycle is 300 N. The wire diameter is 5 mm, and spring index is 5. The spring is made of oil-hardened and tempered steel wire of Grade-SW (s_{yt} = 1440 N/mm^2). Determine the factor of safety against fluctuating stresses. [5+5]

OR

11. A concentric spring consists of two helical compression springs, one inside the other. The free length of the outer spring is 25 mm greater than that of the inner spring. The wire diameter and mean coil diameter of the inner spring are 8 mm and 64 mm respectively. Also, the wire diameter and mean coil diameter of the outer spring are 10 mm and 80 mm respectively. The number of active coils in the inner and outer springs are 10 and 15 respectively. Assume the same material for both the springs. The modulus of rigidity of spring material is 81370 N/mm^2. Calculate the stiffness of spring when the deflection is more than 25 mm. [10]

---ooOoo---

Methods of Riveting:

The function of rivets in a joint is to make a connection that has strength and tightness. The strength is necessary to prevent failure of the joint. The tightness is necessary in order to contribute to strength and to present leakage as in a boiler or in a ship hull. When two plates are to be fastened together by a rivet as shown in Fig. (a), the holes in the plates are punched and reamed or drilled. Punching is the cheapest method and is used for relatively thin plates and in structural work. Since punching injures the material around the hole, therefore drilling is used in most pressure-vessel work. In structural and pressure vessel riveting, the diameter of the rivet hole is usually 1.5 mm larger than the nominal diameter of the rivet

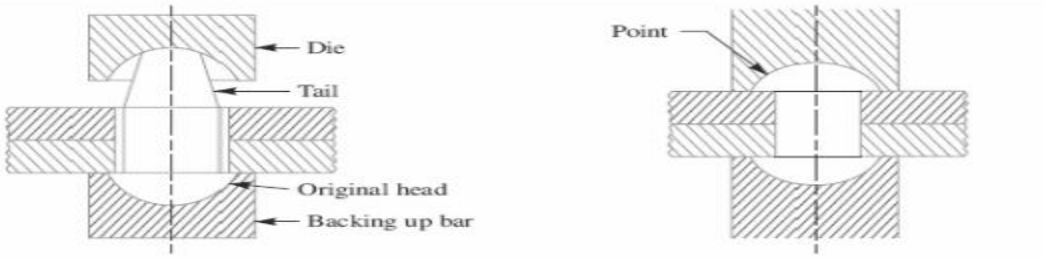


Fig. Methods of riveting.

The plates are drilled together and then separated to remove any burrs or chips so as to have a tight flush joint between the plates. A cold rivet or a red hot rivet is introduced into the plates and the point (i.e. second head) is then formed. When a cold rivet is used, the process is known as cold riveting and when a hot rivet is used, the process is known as hot riveting. The cold riveting process is used for structural joints while hot riveting is used to make leak proof joints.

The riveting may be done by hand or by a riveting machine. In hand riveting, the original rivet head is backed up by a hammer or heavy bar and then the die or set, as shown in Fig.(a), is placed against the end to be headed and the blows are applied by a hammer. This causes the shank to expand thus filling the hole and the tail is converted into a point as shown in Fig.(b). As the rivet cools, it tends to contract. The lateral contraction will be slight, but there will be a longitudinal tension introduced in the rivet which holds the together.

In machine riveting, the die is a part of the hammer which is operated by air, hydraulic or steam pressure.

1. For steel rivets up to 12 mm diameter, the cold riveting process may be used while for larger diameter rivets, hot riveting process is used.

2. In case of long rivets, only the tail is heated and not the whole shank.

Types of Rivet Heads:

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According to Indian standard specifications, the rivet heads are classified into the following three types:

1. Rivet heads for general purposes (below 12 mm diameter) as shown in Fig.

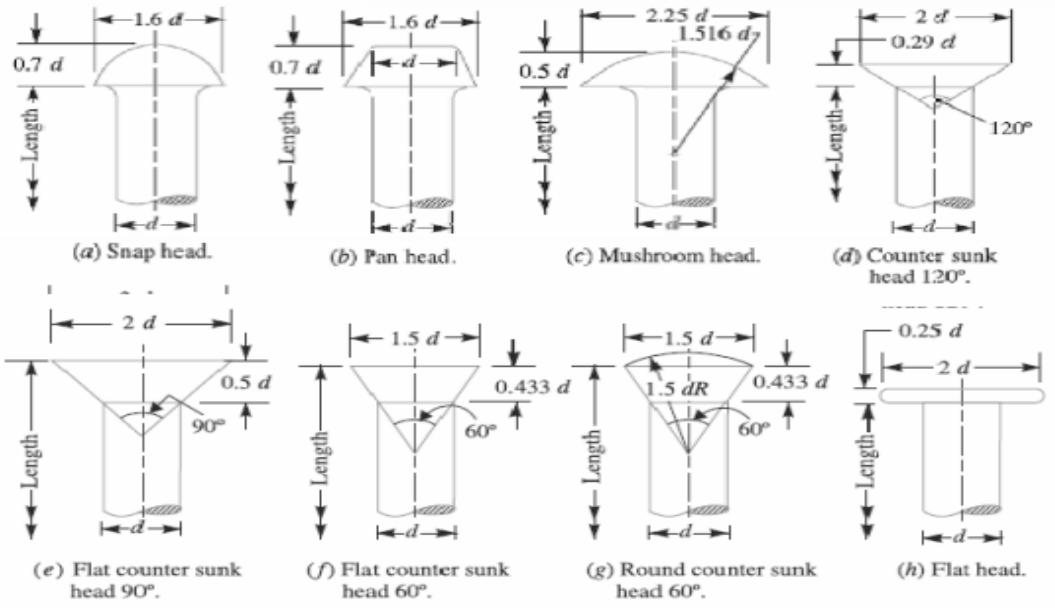
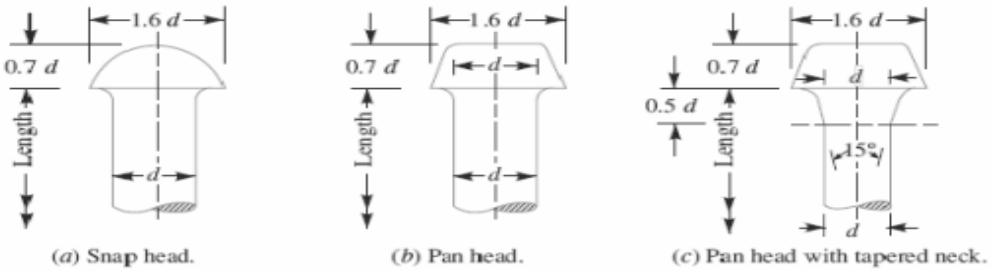


Fig. Rivet heads for general purposes (below 12 mm diameter).

2. Rivet heads for general purposes (From 12 mm to 48 mm diameter) as shown in Fig.



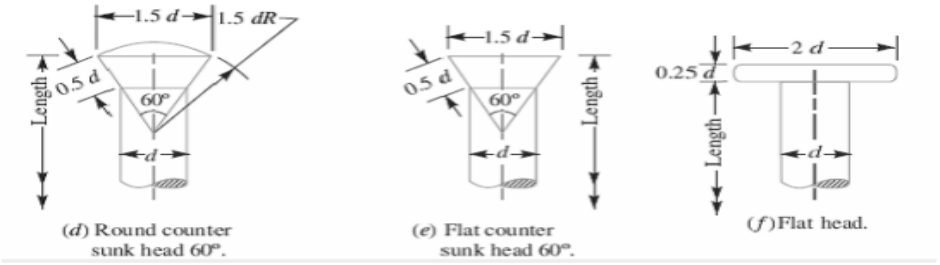
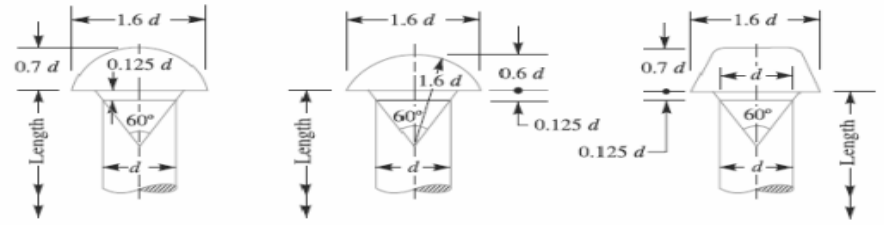
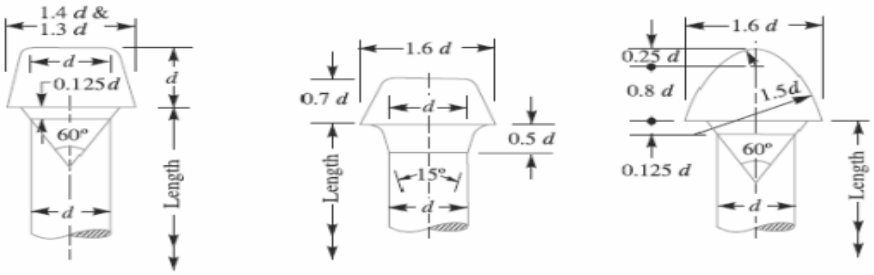


Fig. Rivet heads for general purposes (from 12 mm to 48 mm diameter)

3. Rivet heads for boiler work (from 12 mm to 48 mm diameter, as shown in Fig.





1. Lap joint, and
2. Butt joint.

1. Lap Joint

A lap joint is that in which one plate overlaps the other and the two plates are then riveted together.

2. Butt Joint

A butt joint is that in which the main plates are kept in alignment butting (i.e. touching) each other and a cover plate (i.e. strap) is placed either on one side or on both sides of the main plates. The cover plate is then riveted together with the main plates. Butt joints are of the following two types:

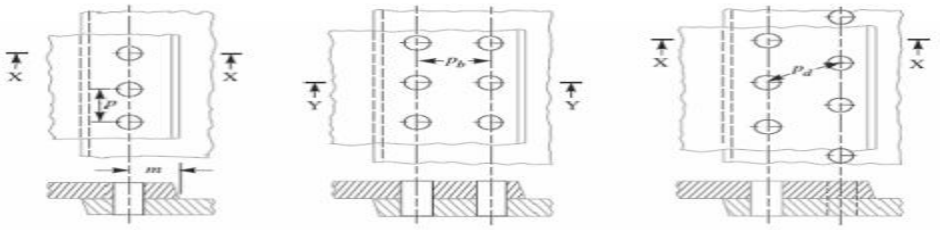
1. Single strap butt joint, and
2. Double strap butt joint.

In a single strap butt joint, the edges of the main plates butt against each other and only one cover plate is placed on one side of the main plates and then riveted together. In a double strap butt joint, the edges of the main plates butt against each other and two cover plates are placed on both sides of the main plates and then riveted together. In addition to the above, following are the types of riveted joints depending upon the number of rows of the rivets.

1. Single riveted joint, and

2. Double riveted joint.

A **single riveted joint** is that in which there is a single row of rivets in a lap joint as shown in Fig (a) and there is a single row of rivets on each side in a butt joint as shown in Fig. A **double riveted joint** is that in which there are two rows of rivets in a lap joint as shown in Fig. (b) and (c) and there are two rows of rivets on each side in a butt joint as shown in Fig.



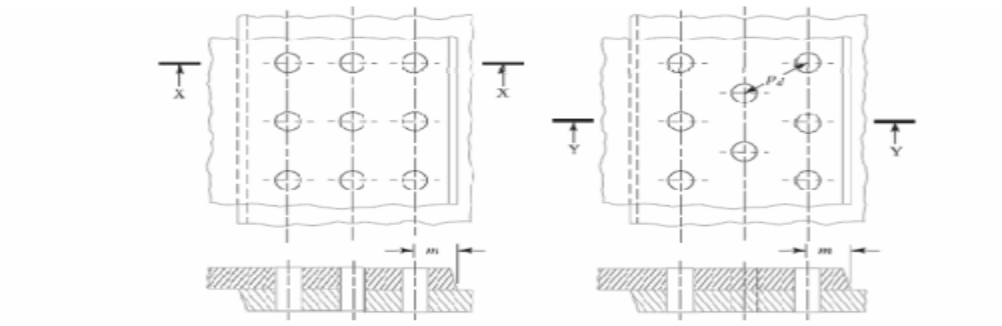
(a) Single riveted lap joint. (b) Double riveted lap joint (Chain riveting). (c) Double riveted lap Joint (Zig-zag riveting).

Fig. Single and double riveted lap joints.

Similarly the joints may be **triple riveted** or **quadruple riveted.**

Notes: 1. when the rivets in the various rows are opposite to each other, as shown in Fig. (b), then the joint is said to be **chain riveted.** On the other hand, if the rivets in the adjacent rows are staggered in such a way that every rivet is in the middle of the two rivets of the opposite row as shown in Fig. (c), then the joint is said to be z**ig-zag riveted.**

2. Since the plates overlap in lap joints, therefore the force P, P acting on the plates are not in the same straight line but they are at a distance equal to the thickness of the plate. These forces will form a couple which may bend the joint. Hence the lap joints may be used only where small loads are to be transmitted. On the other hand, the forces P, P in a butt joint act in the same straight line, therefore there will be no couple. Hence the butt joints are used where heavy loads are to be transmitted.



(a) Chain riveting. (b) Zig-zag riveting.

Fig. 9.7. Triple riveted lap joint.

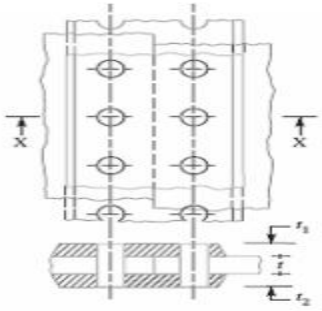
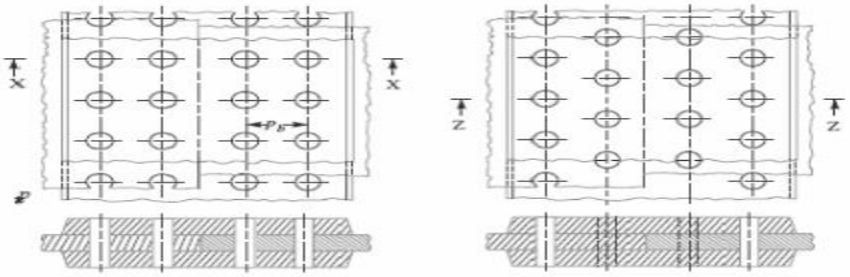


Fig. Single riveted double strap butt joint.



(a) Chain a riveting. (b) Zig-zag riveting

Fig. Double riveted double strap (equal) butt joints.

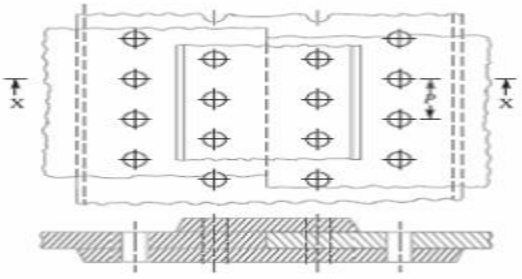


Fig. Double riveted double strap (unequal) butt joint with zig-zag riveting.

Caulking and Fullering :

In order to make the joints leak proof or fluid tight in pressure vessels like steam boilers, air receivers and tanks etc. a process known as caulking is employed. In this process, a narrow blunt tool called caulking tool, about 5 mm thick and 38 mm in breadth, is used. The edge of the tool is ground to an angle of 80°. The tool is moved after each blow along the edge of the plate, which is planed to a level of 75° to 80° to facilitate the forcing down of edge. It is seen that the tool burrs down the plate at A in Fig.2 (a) forming a metal to metal joint. In actual practice, both the edges at A and B are caulked. The head of the rivets as shown at C are also

turned down with a caulking tool to make a joint steam tight. A great care is taken to prevent injury to the plate below the tool.

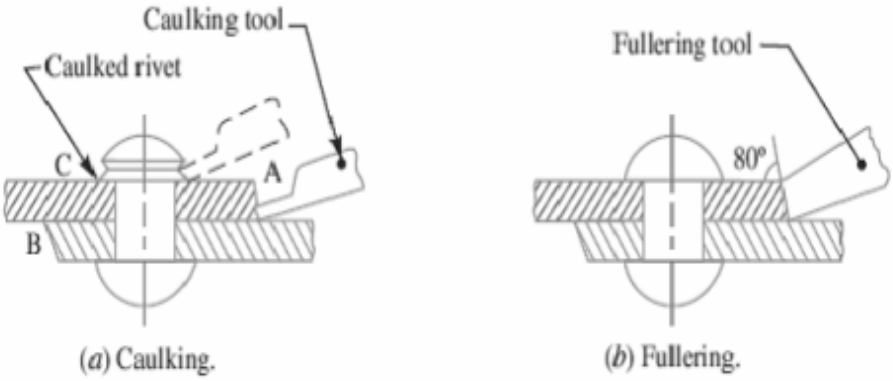


Fig.2. Caulking and fullering.

A more satisfactory way of making the joints staunch is known as **fullering** which has largely superseded caulking. In this case, a fullering tool with a thickness at the end equal to that of the plate is used in such a way that the greatest pressure due to the blows occur near the joint, giving a clean finish, with less risk of damaging the plate. A fullering process is shown in Fig. (b).

Introduction to Welded Joints

Introduction

A welded joint is a permanent joint which is obtained by the fusion of the edges of the two parts to be joined together, with or without the application of pressure and a filler material. The heat required for the fusion of the material may be obtained by burning of gas (in case of gas welding) or by an electric arc (in case of electric arc welding). The latter method is extensively used because of greater speed of welding. Welding is extensively used in fabrication as an alternative method for casting or forging and as a replacement for bolted and riveted joints. It is also used as a repair medium *e.g.* to reunite metal at a crack, to build up a small part that has broken off such as gear tooth or to repair a worn surface such as a bearing surface.

Advantages and Disadvantages of Welded Joints over Riveted Joints

Following are the advantages and disadvantages of welded joints over riveted joints.

Advantages

1. The welded structures are usually lighter than riveted structures. This is due to the reason, that in welding, gussets or other connecting components are not used.

2. The welded joints provide maximum efficiency (may be 100%) which is not possible in case of riveted joints.

3. Alterations and additions can be easily made in the existing structures.

4. As the welded structure is smooth in appearance, therefore it looks pleasing.

5. In welded connections, the tension members are not weakened as in the case of riveted joints.

6. A welded joint has a great strength. Often a welded joint has the strength of the parent metal itself.

7. Sometimes, the members are of such a shape (*i.e.* circular steel pipes) that they afford difficulty for riveting. But they can be easily welded.

8. The welding provides very rigid joints. This is in line with the modern trend of providing rigid frames.

9. It is possible to weld any part of a structure at any point. But riveting requires enough clearance.

10. The process of welding takes less time than the riveting.

Disadvantages

1. Since there is an uneven heating and cooling during fabrication, therefore the members may get distorted or additional stresses may develop.

2. It requires a highly skilled labour and supervision.

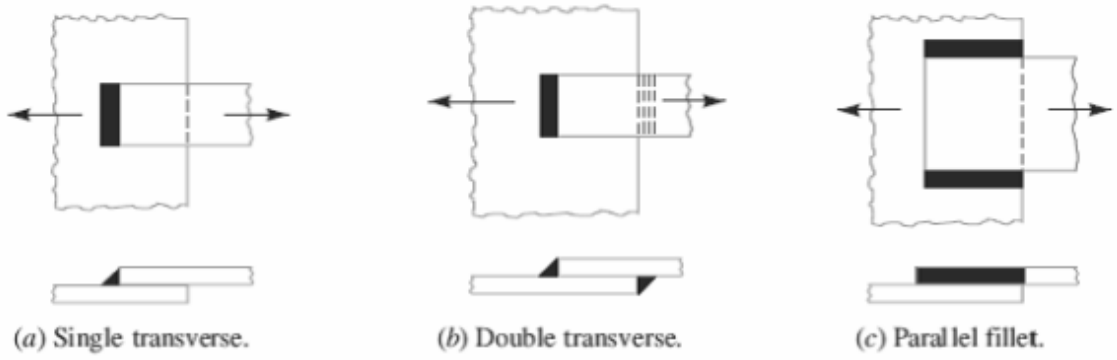
3. Since no provision is kept for expansion and contraction in the frame, therefore there is a possibility of cracks developing in it.

4. The inspection of welding work is more difficult than riveting work.

Types of Welded Joints

Following two types of welded joints are important from the subject point of view:

1. Lap joint or fillet joint, and **2.** Butt joint.



(*a*) Single transverse. (*b*) Double transverse. (*c*) Parallel fillet.

Fig.1. Types of Lab and Butt Joints

Lap Joint

The lap joint or the fillet joint is obtained by overlapping the plates and then welding the edges of the plates. The cross-section of the fillet is approximately triangular. The fillet joints may be

1. Single transverse fillet, **2.** Double transverse fillet and **3.** Parallel fillet joints.

The fillet joints are shown in Fig.1. A single transverse fillet joint has the disadvantage that the edge of the plate which is not welded can buckle or warp out of shape.

Butt Joint

The butt joint is obtained by placing the plates edge to edge as shown in Fig.2. In butt welds, the plate edges do not require beveling if the thickness of plate is less than 5 mm. On the other hand, if the plate thickness is 5 mm to 12.5 mm, the edges should be beveled to V or U-groove on both sides.

(*a*) Square butt joint. (*b*) Single *V*-butt joint. (*c*) Single *U*-butt joint. (*d*) Double *V*-butt joint. (*e*) Double *U*-butt joint.

Fig. 2. Types of Butt joints

The butt joints may be

1. Square butt joint, **2.** Single V-butt joint **3.** Single U-butt joint,

4. Double V-butt joint, and **5.** D uble U-butt joint.

These joints are shown in Fig. 2.

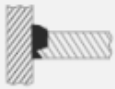
The other type of welded joints are corner joint, edge joint and T-joint as shown in Fig. 3.

(*a*) Corner joint. (*b*) Edge joint. (*c*) *T*-joint.

Fig. 3. Other types of Joints

Basic Weld Symbols

S. No.	*Form of weld*	*Sectional representation*	*Symbol*
1.	Fillet		
2.	Square butt		
3.	Single-*V* butt		
4.	Double-*V* butt		
5.	Single-*U* butt		
6.	Double-*U* butt		
7.	Single bevel butt		
8.	Double bevel butt		

S. No.	Form of weld	Sectional representation	Symbol
9.	Single-*J* butt		
10.	Double-*J* butt		
11.	Bead (edge or seal)		
12.	Stud		
13.	Sealing run		
14.	Spot		
15.	Seam		
16.	Mashed seam	 Before After	
17.	Plug		
18.	Backing strip		
19.	Stitch		
20.	Projection	 Before After	
21.	Flash	 Rod or bar Tube	
22.	Butt resistance or pressure (upset)	 Rod or bar Tube	

Supplementary Weld Symbols

S. No.	Particulars	Drawing representation	Symbol
1.	Weld all round		
2.	Field weld		
3.	Flush contour		—
4.	Convex contour		⌒
5.	Concave contour		⌒
6.	Grinding finish	G	G
7.	Machining finish	M	M
8.	Chipping finish	C	C

Elements of a welding symbol

Elements of a Welding Symbol

A welding symbol consists of the following eight elements:

1. Reference line, **2.** Arrow,

3. Basic weld symbols, **4.** Dimensions and other data,

5. Supplementary symbols, **6.** Finish symbols,

7. Tail, and **8.** Specification, process or other references.

Standard Location of Elements of a Welding Symbol

The arrow points to the location of weld, the basic symbols with dimensions are located on one or both sides of reference line. The specification if any is placed in the tail of arrow. Fig. 1. shows the standard locations of welding symbols represented on drawing.

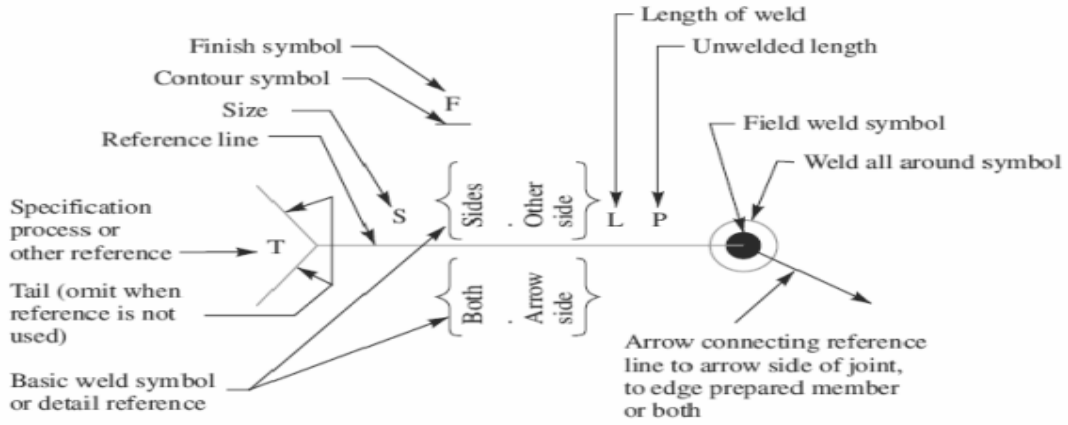
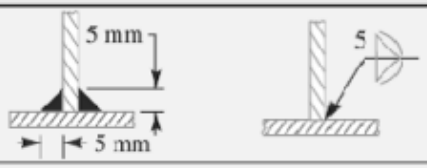
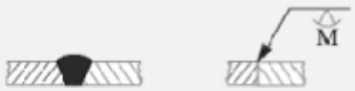
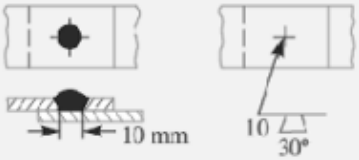
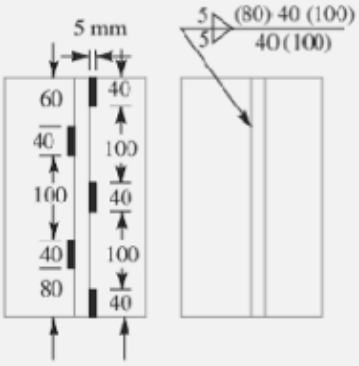


Fig.1 Standard location of weld symbols.

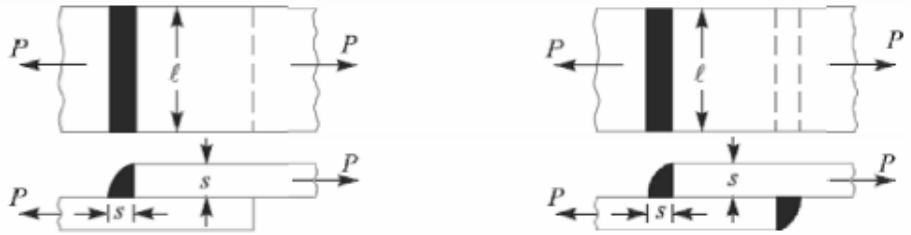
Some of the examples of welding symbols represented on drawing are shown in the following table.

Representation of welding symbols.

S. No.	*Desired weld*	*Representation on drawing*
1.	Fillet-weld each side of Tee- convex contour	
2.	Single V-butt weld -machining finish	
3.	Double V- butt weld	
4.	Plug weld - 30° Groove-angle-flush contour	
5.	Staggered intermittent fillet welds	

Strength of Transverse Fillet Welded Joints

We have already discussed that the fillet or lap joint is obtained by overlapping the plates and then welding the edges of the plates. The transverse fillet welds are designed for tensile strength. Let us consider a singl and double transverse fillet welds as shown in Fig. 1(*a*) and (*b*) respectively.



(*a*) Single transverse fillet weld. (*b*) Double transverse fillet weld.

Fig.1 Transverse fillet welds.

The length of each side is known as ***leg*** or ***size of the weld*** and the perpendicular distance of the hypotenuse from the intersection of legs (*i.e. BD*) is known as ***throat thickness.*** The minimum area of the weld is obtained at the throat *BD*, which is given by the product of the throat thickness and length of weld.

Let t = Throat thickness (*BD*),

s = Leg or size of weld,

= Thickness of plate, and

l = Length of weld,

From Fig.2, we find that the throat thickness,

$$t = s \times \sin 45^\circ = 0.707\, s$$

Therefore, Minimum area of the weld or throat area,

$$A = \text{Throat thickness} \times \text{Length of weld}$$

$$= t \times l = 0.707\, s \times l$$

If σ_t is the allowable tensile stress for the weld metal, then the tensile strength of the joint for single fillet weld,

$$P = \text{Throat area} \times \text{Allowable tensile stress} = 0.707\, s \times l \times \sigma_t$$

And tensile strength of the joint for double fillet weld,

$$P = 2 \times 0.707\, s \times l \times \sigma_t = 1.414\, s \times l \times \sigma_t$$

Note: Since the weld is weaker than the plate due to slag and blow holes, therefore the weld is given a reinforcement which may be taken as 10% of the plate thickness.

Strength of Parallel Fillet Welded Joints

The parallel fillet welded joints are designed for shear strength. Consider a double parallel fillet welded joint as shown in Fig.3 (*a*). We have already discussed in the previous article, that the minimum area of weld or the throat area,

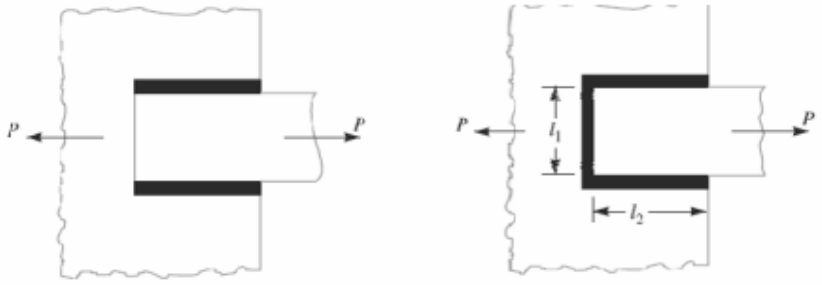
$$A = 0.707\, s \times l$$

If τ is the allowable shear stress for the weld metal, then the shear strength of the joint for single parallel fillet weld,

$$P = \text{Throat area} \times \text{Allowable shear stress} = 0.707\, s \times l \times \tau$$

And shear strength of the joint for double parallel fillet weld,

$$P = 2 \times 0.707 \times s \times l \times \tau = 1.414\, s \times l \times \tau$$



(*a*) Double parallel fillet weld. (*b*) Combination of transverse and parallel fillet weld.

Fig.3

Notes: 1. If there is a combination of single transverse and double parallel fillet welds as shown in Fig. (*b*), then the strength of the joint is given by the sum of strengths of single transverse and double parallel fillet welds. Mathematically,

$$P = 0.707s \times l_1 \times \sigma_t + 1.414\, s \times l_2 \times \tau$$

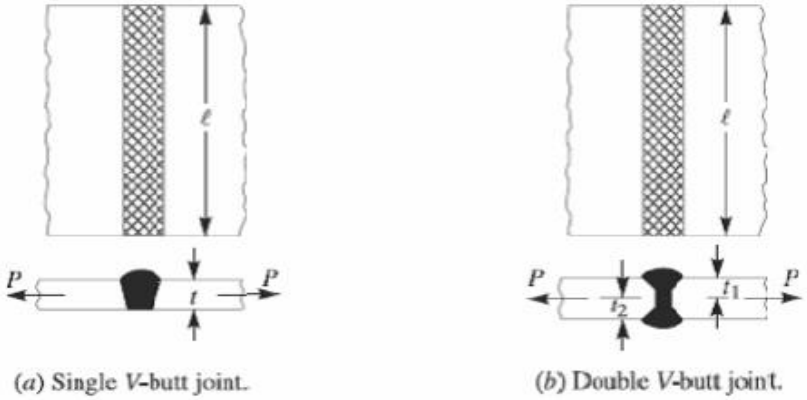
Where l_1 is normally the width of the plate.

2. In order to allow for starting and stopping of the bead, 12.5 mm should be added to the length of each weld obtained by the above expression.

3. For reinforced fillet welds, the throat dimension may be taken as 0.85 *t*.

Strength of Butt Joints

The butt joints are designed for tension or compression. Consider a single V-butt joint as shown in Fig. 4(*a*).



(*a*) Single *V*-butt joint. (*b*) Double *V*-butt joint.

Fig.4. Butt Joints

In case of butt joint, the length of leg or size of weld is equal to the throat thickness which is equal to thickness of plates. Therefore, Tensile strength of the butt joint (single-*V* or square butt joint),

$$P = t \times l \times \sigma_t$$

Where l = Length of weld. It is generally equal to the width of plate. And tensile strength for double-*V* butt joint as shown in Fig. 4(*b*) is given by

$$P = (t_1 + t_2)\, l \times \sigma_t$$

Where t_1 = Throat thickness at the top, and
t_2 = Throat thickness at t e bottom.

It may be noted that size of the weld should be greater than the thickness of the plate, but it may be less. The following table shows recommended minimum size of the welds.

Stresses for Welded Joints

The stresses in welded joints are difficult to determine because of the variable and unpredictable parameters like homogenuity of the weld metal, thermal stresses in the welds, changes of physical properties due to high rate of cooling etc. The stresses are obtained, on the following assumptions:

1. The load is distributed uniformly along the entire length of the weld, and
2. The stress is spread uniformly over its effective section.

The following table shows the stresses for welded joints for joining ferrous metals with mild steel electrode under steady and fatigue or reversed load.

Stress Concentration Factor for Welded Joints

The reinforcement provided to the weld produces stress concentration at the junction of the weld and the parent metal. When the parts are subjected to fatigue loading, the stress concentration factors should be taken into account.

Special Cases of Fillet Welded Joints

The following cases of fillet welded joints are important from the subject point of view.

1. *Circular fillet weld subjected to torsion.* Consider a circular rod connected to a rigid plate by a fillet weld as shown in Fig. 1.

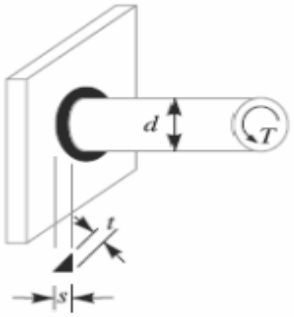


Fig. 1. Circular fillet weld subjected to torsion.

Let d = Diameter of rod,

r = Radius of rod,

T = Torque acting on the rod,

s = Size (or leg) of weld,

t = Throat thickness,

J = Polar moment of inertia of the weld section = $\frac{\pi t d^3}{4}$

We know that shear stress for the material,

$$\tau = \frac{Tr}{J} = \frac{T \times d/2}{J}$$

$$= \frac{T \times d/2}{\pi t d^3/4} = \frac{2T}{\pi t d^2}$$

This shear stress occurs in a horizontal plane along a leg of the fillet weld. The maximum shear occurs on the throat of weld which is inclined at 45° to the horizontal plane.

Length of throat, $t = s \sin 45° = 0.707\, s$ and maximum shear stress,

$$\tau_{max} = \frac{2T}{\pi \times 0.707\, s \times d^2} = \frac{2.83\, T}{\pi\, s\, d^2}$$

2. Circular fillet weld subjected to bending moment. Consider a circular rod connected to a rigid plate by a fillet weld as shown in Fig.2.

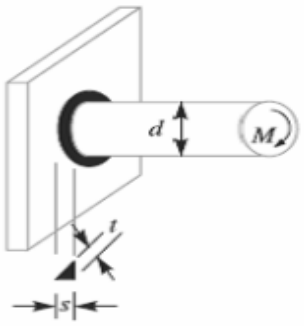


Fig.2.Circular fillet weld subjected to Bending moment.

Let d = Diameter of rod,

M = Bending moment acting on the rod,

s = Size (or leg) of weld,

t = Throat thickness,

The maximum shear stress occurs at the throat and is given by

$$\tau_{max} = \frac{3T}{0.707\, s \times l^2} = \frac{4.242\, T}{s \times l^2}$$

Axially Loaded Unsymmetrical WeldedSections

Sometimes unsymmetrical sections such as angles, channels, *T*-sections etc., welded on the flange edges are loaded axially as shown in Fig. In such cases, the lengths of weld should be proportioned in such a way that the sum of resisting moments of the welds about the gravity axis is zero. Consider an angle section as shown in Fig.

Let l_a = Length of weld at the top,

l_b = Length of weld at the bottom,

l = Total length of weld = $l_a + l_b$

P = Axial load,

a = Distance of top weld from gravity axis,

b = Distance of bottom weld from gravity axis, and

f = Resistance offered by the weld per unit length.

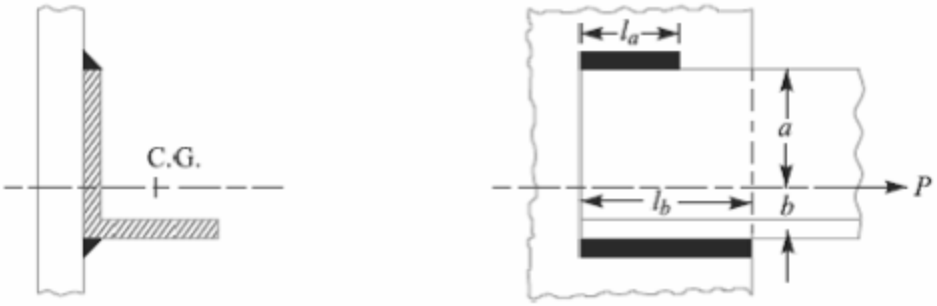


Fig. Axially loaded unsymmetrical welded section

Moment of the top weld about gravity axis

$$= l_a \times f \times a$$

And moment of the bottom weld about gravity axis

$$= l_b \times f \times b$$

Since the sum of the moments of the weld about the gravity axis must be zero, therefore,

$$l_a \times f \times a - l_b \times f \times b = 0$$

$$\text{or } l_a \times a = l_b \times b \qquad \text{...(i)}$$

We know that $l = l_a + l_b$ ...(ii)

From equations **(*i*)** and **(*ii*)**, we have

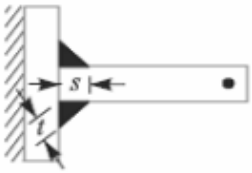
$$l_a = \frac{l \times b}{a + b}, \quad \text{and} \quad l_b = \frac{l \times a}{a + b}$$

Eccentrically Loaded Welded

An eccentric load may be imposed on welded joints in many ways. The stresses induced on the joint may be of different nature or of the same nature. The induced stresses are combined depending upon the nature of stresses. When the shear and bending stresses are simultaneously present in a joint (see case 1), then maximum stresses are as follows:

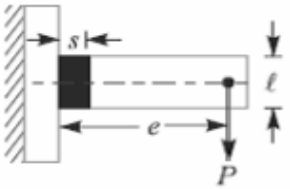
Maximum normal stress,

$$\sigma_{t(max)} = \frac{\sigma_b}{2} + \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2}$$



And Maximum shear stress,

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2}$$



Where σ_b = Bending stress, and

τ = Shear stress.

Fig.1. Eccentrically loaded welded joint

When the stresses are of the same nature, these may be combined vectorially (see case 2).

We shall now discuss the two cases of eccentric loading as follows:

Case 1

Consider a *T*-joint fixed at one end and subjected to an eccentric load *P* at a distance *e* as shown in Fig. 1

Let s = Size of weld,

l = Length of weld, and

t = Throat thickness.

The joint will be subjected to the following two types of stresses:

1. Direct shear stress due to the shear force *P* acting at the welds, and

2. Bending stress due to the bending moment $P \times e$.

We know that area at the throat,

A = Throat thickness × Length of weld

$= t \times l \times 2 = 2\,t \times l$ ... (For double fillet weld)

$= 2 \times 0.707\,s \times l = 1.414\,s \times l$ ... (since, $t = s \cos 45° = 0.707\,s$)

Shear stress in the weld (assumi g uniformly distributed),

$$\tau = \frac{P}{A} = \frac{P}{1.414\,s \times l}$$

Section modulus of the weld metal through the throat,

$$Z = \frac{t \times l^2}{6} \times 2 \qquad \text{...(For both sides weld)}$$

$$= \frac{0.707 s \times l^2}{6} \times 2 = \frac{s \times l^2}{4.242}$$

Bending moment, $M = P \times e$

$$\therefore \text{Bending stress, } \sigma_b = \frac{M}{Z} = \frac{P \times e \times 4.242}{s \times l^2} = \frac{4.242\ P \times e}{s \times l^2}$$

We know that the maximum normal stress,

$$\sigma_{t(max)} = \frac{1}{2}\sigma_b + \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2}$$

And maximum shear stress,

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2}$$

Case 2

When a welded joint is loaded eccentrically as shown in Fig.2, the following two types of the stresses are induced:

1. Direct or primary shear stress, and

2. Shear stress due to turning moment.

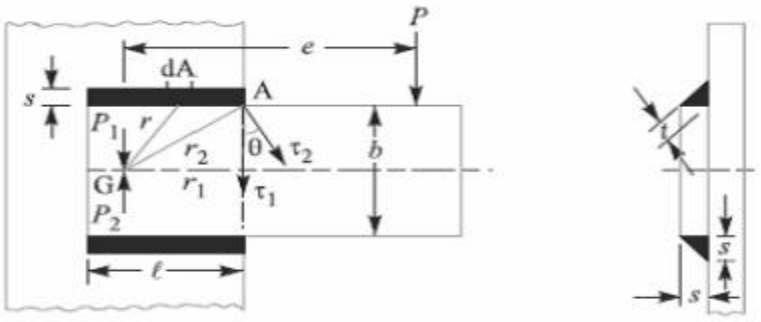


Fig.2 eccentrically loaded welded joint.

Let P = Eccentric load,

e = Eccentricity i.e. perpendicular distance between the line of action of load and centre of gravity (G) of the throat section or fillets,

l = Length of single weld,

s = Size or leg of weld, and

t = Throat thickness.

Let two loads P_1 and P_2 (each equal to P) are introduced at the centre of gravity 'G' of the weld system. The effect of load $P_1 = P$ is to produce direct shear stress which is assumed to be uniform over the entire weld length. The effect of load $P_2 = P$ is to produce a turning moment of magnitude $P \times e$ which tends of rotate the joint about the centre of gravity 'G' of the weld system. Due to the turning moment, secondary shear stress is induced.

We know that the direct or primary shear stress,

$$\tau_1 = \frac{\text{Load}}{\text{Throat area}} = \frac{P}{A} = \frac{P}{2\,t \times l}$$

$$= \frac{P}{2 \times 0.707\,s \times l} = \frac{P}{1.414\,s \times l}$$

Since the shear stress produced due to the turning moment ($T = P \times e$) at any section is proportional to its radial distance from G, therefore stress due to $P \times e$ at the point A is proportional to AG (r2) and is in a direction at right angles to AG. In other words,

$$\frac{\tau_2}{r_2} = \frac{\tau}{r} = \text{Constant}$$

$$\tau = \frac{\tau_2}{r_2} \times r \qquad \ldots(i)$$

Where τ_2 is the shear stress at the maximum distance (r_2) and τ is the shear stress at any distance r. Consider a small section of the weld having area dA at a distance r from G.

Shear force on this small section

$$= \tau \times dA$$

And turning moment of this shear force about G,

$$dT = \tau \times dA \times r = \frac{\tau_2}{r_2} \times dA \times r^2 \qquad \ldots \text{[From equation } (i)\text{]}$$

Total turning moment over the whole weld area,

$$T = P \times e = \int \frac{\tau_2}{r_2} \times dA \times r^2 = \frac{\tau_2}{r_2} \int dA \times r^2$$

$$= \frac{\tau_2}{r_2} \times J \qquad \left(\because J = \int dA \times r^2\right)$$

Where J = Polar moment of inertia of the throat area about G.

□Shear stress due to the turning moment i.e. secondary shear stress,

$$\tau_2 = \frac{T \times r_2}{J} = \frac{P \times e \times r_2}{J}$$

In order to find the resultant stress, the primary and secondary shear stresses are combined vectorially.

Resultant shear stress at A,

$$\tau_A = \sqrt{(\tau_1)^2 + (\tau_2)^2 + 2\tau_1 \times \tau_2 \times \cos\theta}$$

θ = Angle between τ_1 and τ_2, and

$\cos\theta = r_1 / r_2$

Introduction to Screwed Joints:

A screw thread is formed by cutting a continuous helical groove on a cylindrical surface. A screw made by cutting a single helical groove on the cylinder is known as **single threaded** (or single-start) screw and if a second thread is cut in the space between the grooves of the first, a **double threaded** (or double-start) screw is formed. Similarly, triple and quadruple (i.e. multiple-start) threads may be formed. The helical grooves may be cut either **right hand** or **left hand.**

A screwed joint is mainly composed of two elements i.e. a bolt and nut. The screwed joints are widely used where the machine parts are required to be readily connected or disconnected without damage to the machine or the fastening. This may be for the purpose of holding or adjustment in assembly or service inspection, repair, or replacement or it may be for the manufacturing or assembly reasons. The parts may be rigidly connected or provisions may be made for predetermined relative motion.

Advantages and Disadvantages of Screwed Joints

Following are the advantages and disadvantages of the screwed joints.

Advantages

1. Screwed joints are highly reliable in operation.

2. Screwed joints are convenient to assemble and disassemble.

3. A wide range of screwed joints may be adapted to various operating conditions.

4. Screws are relatively cheap to produce due to standardization and highly efficient manufacturing processes.

Disadvantages

The main disadvantage of the screwed joints is the stress concentration in the threaded portions which are vulnerable points under variable load conditions.

Note : The strength of the screwed joints is not comparable with that of riveted or welded joints.

Important Terms Used in Screw Threads

The following terms used in screw threads, as shown in Fig. 1, are important from the subject point of view:

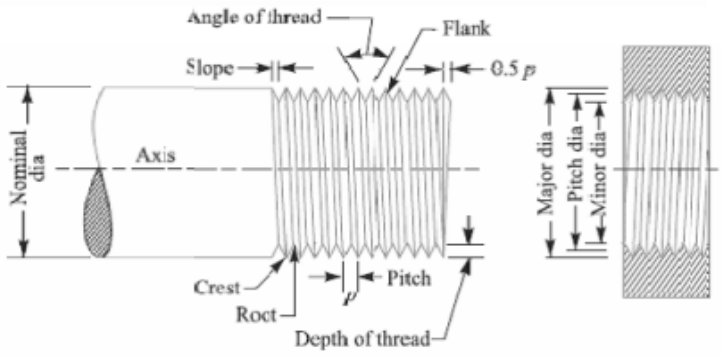


Fig.1 Terms used in screw threads

1. Major diameter. It is the largest diameter of an external or internal screw thread. The screw is specified by this diameter. It is also known as **outside** or **nominal diameter.**

2. Minor diameter. It is the smallest diameter of an external or internal screw thread. It is also known as **core** or **root diameter.**

3. Pitch diameter. It is the diameter of an imaginary cylinder, on a cylindrical screw thread, the surface of which would pass through the thread at such points as to make equal the width of the thread and the width of the spaces between the threads. It is also called an **effective diameter.** In a nut and bolt assembly, it is the diameter at which the ridges on the bolt are in complete touch with the ridges of the corresponding nut.

4. Pitch. It is the distance from a point on one thread to the corresponding point on the next. This is measured in an axial direction between corresponding points in the same axial plane. Mathematically,

$$\text{Pitch} = \frac{1}{\text{No. of threads per unit length of screw}}$$

5. Lead. It is the distance between two corresponding points on the same helix. It may also be defined as the distance which a screw thread advances axially in one rotation of the nut. Lead is equal to the pitch in case of single start threads, it is twice the pitch in double start, thrice the pitch in triple start and so on.

6. Crest. It is the top surface of the thread.

7. Root. It is the bottom surface created by the two adjacent flanks of the thread.

8. Depth of thread. It is the per endicular distance between the crest and root.

9. Flank. It is the surface joining the crest and root.

10. Angle of thread. It is the angle included by the flanks of the thread.

11. Slope. It is half the pitch of the thread

Stresses in Screwed Fastening due to Static Loading

The following stresses in screwed fastening due to static loading are important from the subject point of view:

1. Internal stresses due to screwing up forces,

2. Stresses due to external forces, and

3. Stress due to combination of stresses at (1) and (2).

Initial Stresses due to Screwing up Forces

The following stresses are induced in a bolt, screw or stud when it is screwed up tightly.

1. Tensile stress due to stretching of bolt. Since none of the above mentioned stresses are accurately determined, therefore bolts are designed on the basis of direct tensile stress with a large factor of safety in order to account for the indeterminate stresses. The initial tension in a bolt, based on experiments, may be found by the relation

$$P_i = 2840\ d\ N$$

Where P_i = Initial tension in a bolt, and

d = Nominal diameter of bolt, in mm.

The above relation is used for making a joint fluid tight like steam engine cylinder cover joints etc. When the joint is not required as tight as fluid-tight joint, then the initial tension in a bolt may be reduced to half of the above value. In such cases

$$P_i = 1420\ d\ N$$

The small diameter bolts may fail during tightening, therefore bolts of smaller diameter (less than M 16 or M 18) are not permitted in making fluid tight joints. If the bolt is not initially stressed, then the maximum safe axial load which may be applied to it, is given by

P = Permissible stress × Cross-sectional area at bottom of the thread

$$\text{Stress area} = \frac{\pi}{4}\left(\frac{d_p + d_c}{2}\right)^2$$

Where d_p = Pitch diameter, and

d_c = Core or minor diameter.

Stresses due to External Forces

The following stresses are induced in a bolt when it is subjected to an external load.

1. Tensile stress. The bolts, studs and screws usually carry a load in the direction of the bolt axis which induces a tensile stress in the bolt.

Let d_c = Root or core diameter of the thread, and

σ_t = Permissible tensile stress for the bolt material.

We know that external load applied,

$$P = \frac{\pi}{4}(d_c)^2\ \sigma_t$$

$$d_c - \sqrt{\frac{4\,P}{\pi\,\sigma_t}}$$

Notes: (a) if the external load is taken up by a number of bolts, then

$$P = \frac{\pi}{4}(d_c)^2\ \sigma_t \times n$$

(b) In case the standard table is not available, then for coarse threads, $d_c = 0.84\ d$, where d is the nominal diameter of bolt.

2. Shear stress. Sometimes, the bolts are used to prevent the relative movement of two or more parts, as in case of flange coupling, and then the shear stress is induced in the bolts. The shear stresses should be avoided as far as possible. It should be noted that when the bolts are subjected to direct shearing loads, they should be located in such a way that the shearing load comes upon the body (i.e. shank) of the bolt and not upon the threaded portion. In some cases, the bolts may be relieved of shear load by using shear pins. When a number of bolts are used to share the shearing load, the finished bolts should be fitted to the reamed holes.

Let d = Major diameter of the bolt, and

n = Number of bolts.

Shearing load carried by the bolts,

$$P_s = \frac{\pi}{4} \times d^2 \times \tau \times n \quad \text{or} \quad d = \sqrt{\frac{4\,P_s}{\pi \tau n}}$$

3. Combined tension and shear stress. When the bolt is subjected to both tension and shear loads, as in case of coupling bolts or bearing, then the diameter of the shank of the bolt is obtained from the shear load and that of threaded part from the tensile load. A diameter slightly larger than that required for either shear or tension may be assumed and stresses due to combined load should be checked for the following principal stresses.

Maximum principal shear stress,

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_t)^2 + 4\tau^2}$$

And maximum principal tensile stress,

$$\sigma_{t(max)} = \frac{\sigma_t}{2} + \frac{1}{2}\sqrt{(\sigma_2)^2 + 4\tau^2}$$

Stress due to Combined Forces

The resultant axial load on a bolt depends upon the following factors:

1. The initial tension due to tightening of the bolt,

2. The external load, and

3. The relative elastic yielding (springiness) of the bolt and the connected members.

When the connected members are very yielding as compared with the bolt, which is a soft gasket, as shown in Fig. 1 (*a*), then the resultant load on the bolt is approximately equal to the sum of the initial tension and the external load. On the other hand, if the bolt is very yielding as compared with the connected members, as shown in Fig. 1(*b*), then the resultant load will be either the initial tension or the external load, whichever is greater. The actual conditions usually lie between the two extremes. In order to determine the resultant axial load (P) on the bolt, the following equation may be used :

$$P = P_1 + \frac{a}{1+a} \times P_2 = P_1 + K.P_2 \quad \ldots \left(\text{Substituting } \frac{a}{1+a} = K \right)$$

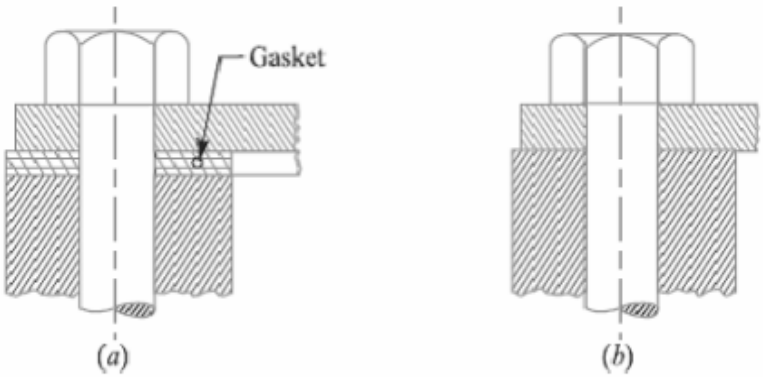


Fig.1

Where P_1 = Initial tension due to tightening of the bolt,

P_2 = External load on the bolt, and

a = Ratio of elasticity of connected parts to the elasticity of bolt.

For soft gaskets and large bolts, the value of a is high and the value of a/ (1+a) is approximately equal to unity, so that the resultant load is equal to the sum of the initial tension and the external load. For hard gaskets or metal to metal contact surfaces and with small bolts, the value of a is small and the resultant load is mainly due to the initial tension (or external load, in rare case it is greater than initial tension). The value of 'a' may be estimated by the designer to obtain an approximate value for the resultant load. The values of

a/(1+ *a)* (*i.e. K*) for various type of joints are shown in the following table. The designer thus has control over the influence on the resultant load on a bolt by proportioning the sizes of the connected parts and bolts and by specifying initial tension in the bolt.

Values of K for various types of joints.

Type of joint	$K = \frac{a}{1+a}$
Metal to metal joint with through bolts	0.00 to 0.10
Hard copper gasket with long through bolts	0.25 to 0.50
Soft copper gasket with long through bolts	0.50 to 0.75
Soft packing with through bolts	0.75 to 1.00
Soft packing with studs	1.00

Design of Cylinder Covers

The cylinder covers may be secured by means of bolts or studs, but studs are preferred. The possible arrangement of securin the cover with bolts and studs is shown in Fig. 2 (*a*) and (*b*) respectively. The bolts or studs, cylinder cover plate and cylinder flange may be designed as discussed below:

1. Design of bolts or studs

In order to find the size and number of bolts or studs, the following procedure may be adopted.

Let D = Diameter of the cylinder,

p = Pressure in the cylinder,

d_c = Core diameter of the bolts or studs,

n = Number of bolts or studs, and

σ_{tb} = Permissible tensile stress for the bolt or stud material.

We know that upward force acting on the cylinder cover,

$$P = \frac{\pi}{4} (D^2)\, p \qquad ...(i)$$

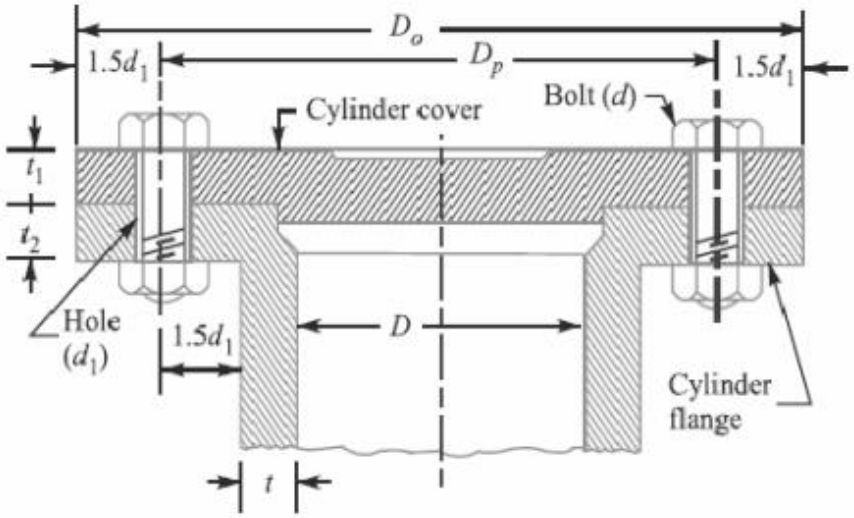
This force is resisted by n number of bolts or studs provided on the cover.

Resisting force offered by n number of bolts or studs,

$$P = \frac{\pi}{4} (d_c)^2\, \sigma_{tb} \times n \qquad ...(ii)$$

From equations **(*i*)** and **(*ii*)**, we have

$$\frac{\pi}{4}(D^2)\, p = \frac{\pi}{4}(d_c)^2\, \sigma_{tb} \times n \qquad ...(ii)$$



(a) Arrangement of securing the cylinder cover with bolts.

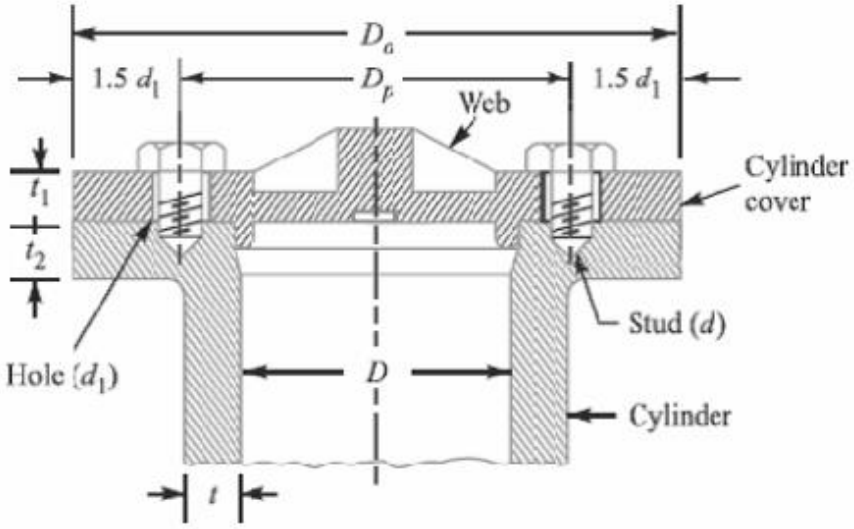


Fig. 2.

From this equation, the number of bolts or studs may be obtained, if the size of the bolt or stud is known and *vice-versa*. Usually the size of the bolt is assumed. If the value of n as obtained from the above relation is odd or a fraction, then next higher even number is adopted. The bolts or studs are screwed up tightly, along with metal gasket or asbestos packing, in order to provide a leak proof joint. We have already discussed that due to the tightening of bolts, sufficient tensile stress is produced in the bolts or studs. This may break the bolts or studs, even before any load due to internal pressure acts upon them. Therefore a bolt or a stud less than 16 mm diameter should never be used.

The tightness of the joint also depends upon the circumferential pitch of the bolts or studs. The circumferential pitch should be between 20 d_1 and 30 d_1 , where d_1 is the diameter of the hole in mm for bolt or stud. The pitch circle diameter (D_p) is usually taken as $D + 2t + 3d_1$ and outside diameter of the cover is kept as

$$D_0 = Dp + 3d_1 = D + 2t + 6d_1$$

where t = Thickness of the cylinder wall.

2. Design of cylinder cover plate

The thickness of the cylinder cover plate (t_1) and the thickness of the cylinder flange (t_2) may be determined as discussed below:

Let us consider the semi-cover plate as shown in Fig. 3. The internal pressure in the cylinder tries to lift the cylinder cover while the bolts or studs try to retain it in its position. But the centres of pressure of these two loads do not coincide. Hence, the cover plate is subjected to bending stress. The point X is the centre of pressure for bolt load and the point Y is the centre of internal pressure.

We know that the bending moment at A-A,

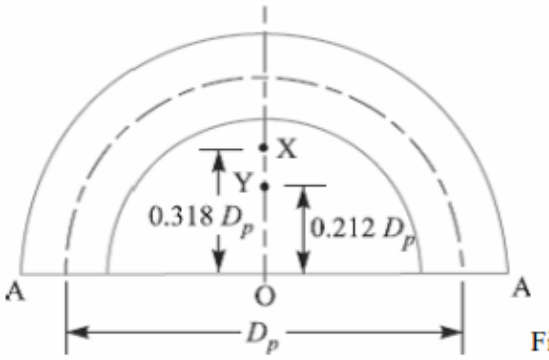


Fig.3

$$M = \frac{\text{Total bolt load}}{2}(OX - OY) = \frac{P}{2}(0.318\ D_P - 0.212\ D_P)$$

$$= \frac{P}{2} \times 0.106\ D_p = 0.053\ P \times D_p$$

$$Z = \frac{1}{6} w\ (t_1)^2$$

Where w = Width of plate

= Outside dia. of cover plate – 2 × dia. of bolt hole

= $D_0 - 2d_1$

Knowing the tensile stress for the cover plate material, the value of t_1 may be determined by using the bending equation,

i.e., $\sigma t = M / Z$.

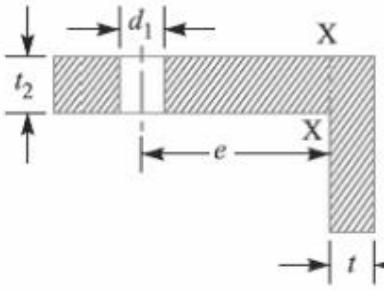


Fig.4

3. Design of cylinder flange

The thickness of the cylinder flange (t_2) may be determined from bending consideration. A portion of the cylinder flange under the influence of one bolt is shown in Fig. 4. The load in the bolt produces bending stress in the section *X-X*. From the geometry of the figure, we find that eccentricity of the load from section *X-X* is

e = Pitch circle radius – (Radius of bolt hole +Thickness of cylinder wall)

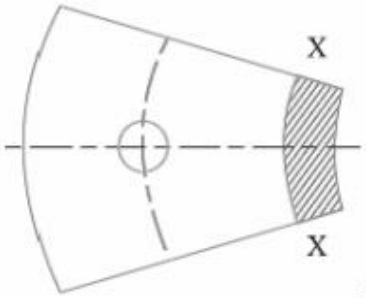


Fig.5

$$= \frac{D_p}{2} - \left(\frac{d_1}{2} + t\right)$$

Bending moment, M = Load on each bolt × e

$$= \frac{P}{n} \times e$$

R = Cylinder radius + Thickness of cylinder wall

$$= \frac{D}{2} + t$$

Width of the section *X-X*,

$$w = \frac{2\pi R}{n}$$, Where n is the number of bolts.

Section modulus,

$$Z = \frac{1}{6} w (t_2)^2$$

Knowing the tensile stress for the cylinder flange material, the value of t_2 may be obtained by using the bending equation *i.e.* $\sigma_t = M / Z$.

Eccentric Load Acting Parallel to the Axis of Bolts

Consider a bracket having a rectangular base bolted to a wall by means of four bolts as shown in Fig.1. A little consideration will show that each bolt is subjected to a direct tensile load of

$$W_{t1} = \frac{W}{n}$$, where n is the number of bolts.

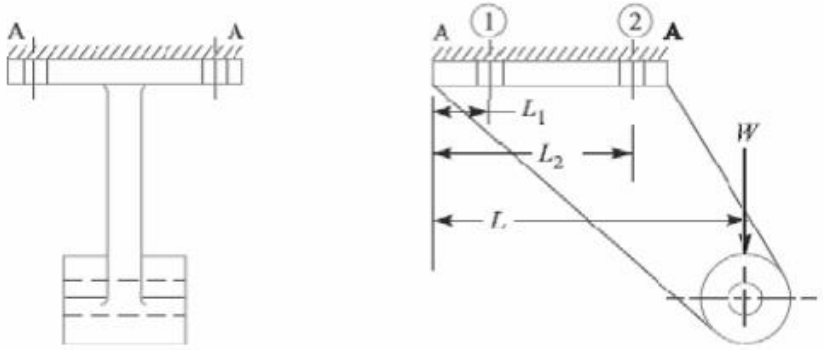


Fig.1. Eccentric load acting parallel to the axis of bolts.

Further the load W tends to rotate the bracket about the edge *A-A*. Due to this, each bolt is stretched by an amount that depends upon its distance from the tilting edge. Since the stress is a function of elongation, therefore each bolt will experience a different load which also depends upon the distance from the tilting edge. For convenience, all the bolts are made of same size. In case the flange is heavy, it may be considered as a rigid body.

Let w be the load in a bolt per unit distance due to the turning effect of the bracket and let W_1 and W_2 be the loads on each of the bolts at distances L_1 and L_2 from the tilting edge.

Load on each bolt at distance L_1,

$$W_1 = w.L_1$$

And moment of this load about the tilting edge

$$= w.L_1 \times L_1 = w (L_1)^2$$

Similarly, load on each bolt at distance L_2,

$$W_2 = w.L_2$$

And moment of this load about the tilting edge

$$= w.L_2 \times L_2 = w (L_2)^2$$

So, Total moment of the load on the bolts about the tilting edge

$$= 2w (L_1)^2 + 2w (L_2)^2 \quad \textbf{...(i)}$$

... (Since, there are two bolts each at distance of L_1 and L_2)

Also the moment due to load W about the tilting edge

$$= W.L \text{ ... } (ii)$$

From equations **(*i*)** and **(*ii*)**, we have

$$W.L = 2w(L_1)^2 + 2w(L_2)^2 \qquad \text{or} \qquad w = \frac{W.L}{2[(L_1)^2 + (L_2)^2]} \qquad ...(iii)$$

It may be noted that the most heavily loaded bolts are those which are situated at the greatest distance from the tilting edge. In the case discussed above, the bolts at distance $L2$ are heavily loaded.

So, Tensile load on each bolt at distance L_2,

$$W_{t2} = W_2 = w.L_2 = \frac{W.L.L_2}{2[(L_1)^2 + (L_2)^2]} \qquad \text{... [From equation } (iii)]$$

And the total tensile load on the most heavily loaded bolt,

$$W_t = W_{t1} + W_{t2} \text{ ... } (iv)$$

If d_c is the core diameter of the olt and σt is the tensile stress for the bolt material, then total tensile load,

$$W_t = \frac{\pi}{4}(d_c)^2 \sigma_t \qquad ...(v)$$

From equations **(*iv*)** and **(*v*)**, the value of dc may be obtained.

Eccentric Load Acting Perpendicular to the Axis of Bolts

A wall bracket carrying an eccentric load perpendicular to the axis of the bolts is shown in Fig.2.

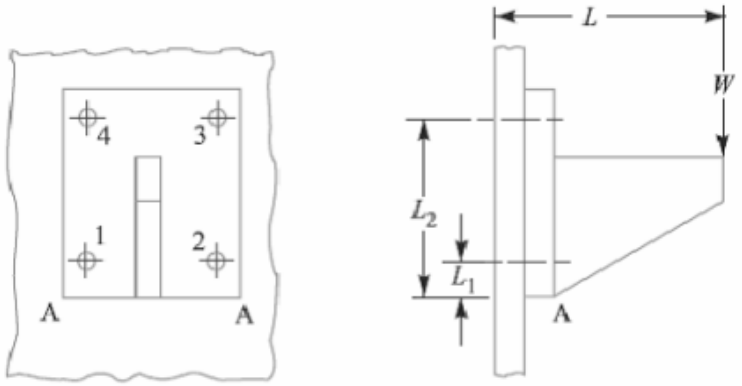


Fig. 2. Eccentric load perpendicular to the axis of bolts.

In this case, the bolts are subjected to direct shearing load which is equally shared by all the bolts. Therefore direct shear load on each bolts,

$W_s = W/n$, where n is number of bolts.

A little consideration will show that the eccentric load W will try to tilt the bracket in the clockwise direction about the edge *A-A*. As discussed earlier, the bolts will be subjected to tensile stress due to the turning moment. The maximum tensile load on a heavily loaded bolt (W_t) may be obtained in the similar manner as discussed in the previous article. In this case, bolts 3 and 4 are heavily loaded.

Maximum tensile load on bolt 3 or 4,

$$W_{t2} = W_t = \frac{W.L.L_2}{2\left[(L_1)^2 + (L_2)^2\right]}$$

When the bolts are subjected to shear as well as tensile loads, then the equivalent loads may be determined by the following relations:

Equivalent tensile load,

$$W_{te} = \frac{1}{2}\left[W_t + \sqrt{(W_t)^2 + 4(W_s)^2}\right]$$

And equivalent shear load,

$$W_{se} = \frac{1}{2}\left[\sqrt{(W_t)^2 + 4(W_s)^2}\right]$$

Knowing the value of equivalent loads, the size of the bolt may be determined for the given allowable stresses.

Eccentric Load on a Bracket with Circular Base

Sometimes the base of a bracket is made circular as in case of a flanged bearing of a heavy machine tool and pillar crane etc. Consider a round flange bearing of a machine tool having four bolts as shown in Fig. 1.

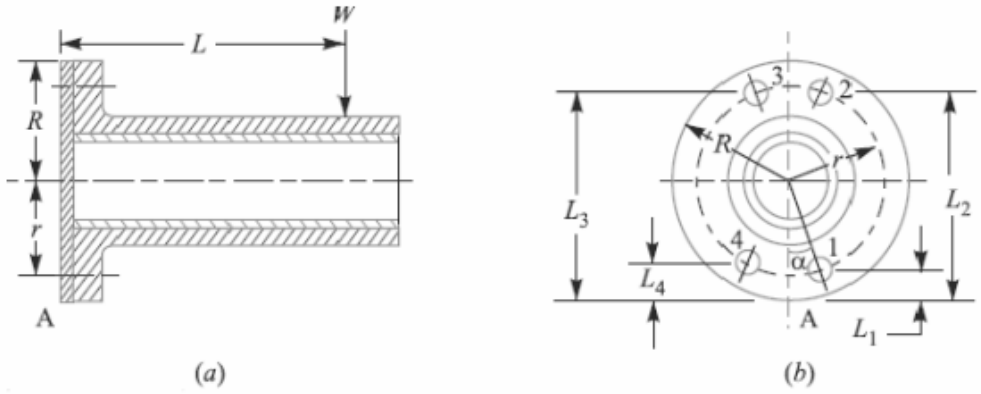


Fig.1. Ecce tric load on a bracket with circular base.

Let R = Radius of the column flange,

r = Radius of the bolt pitch circle,

w = Load per bolt per unit distance from the tilting edge,

L = Distance of the load from the tilting edge, and

L_1, L_2, L_3, and L_4 = Distance of bolt centers from the tilting edge A.

As discussed in the previous article, equating the external moment $W \times L$ to the sum of the resisting moments of all the bolts, we have,

$$WL = w[(L_1)^2 + (L_2)^2 + (L_3)^2 + (L_4)^2]$$

$$\therefore \quad w = \frac{W.L}{(L_1)^2 + (L_2)^2 + (L_3)^2 + (L_4)^2} \qquad \ldots(i)$$

Now from the geometry of the Fig. 1(b), we find that

$$L_1 = R - r\cos\alpha \quad L_2 = R + r\sin\alpha$$

$$L_3 = R + r\cos\alpha \text{ and } L_4 = R - r\sin\alpha$$

Substituting these values in equation (i), we get

$$w = \frac{W.L}{4R^2 + 2r^2}$$

Load in the bolt situated at 1 = $w.L_1$ =

$$\frac{W.L.L_1}{4R^2 + 2r^2} = \frac{W.L(R - r\cos\alpha)}{4R^2 + 2r^2}$$

This load will be maximum when cos α is minimum *i.e.* when cos α = – 1 or α = 180°.

Maximum load in a bolt

$$= \frac{W.L\,(R + r)}{4\,R^2 + 2\,r^2}$$

In general, if there are n number of bolts, then load in a bolt

$$= \frac{2W.L\,(R - r\cos\alpha)}{n\,(2R^2 + r^2)}$$

And maximum load in a bolt,

$$W_t = \frac{2\,W.L\,(R + r)}{n\,(2R^2 + r^2)}$$

The above relation is used when the direction of the load W changes with relation to the bolts as in the case of pillar crane. But if the direction of load is fixed, then the maximum load on the bolts may be reduced by locating the bolts in such a way that two of them are equally stressed as shown in Fig.2. In such a case, maximum load is given by

$$W_t = \frac{2\,W.L}{n}\left[\frac{R + r\cos\left(\frac{180}{n}\right)}{2R^2 + r^2}\right]$$

Knowing the value of maximum load, we can determine the size of the bolt.

Note: Generally, two dowel pins as shown in Fig. 2, are used to take up the shear load. Thus the bolts are relieved of shear stress and the bolts are designed for tensile load only.

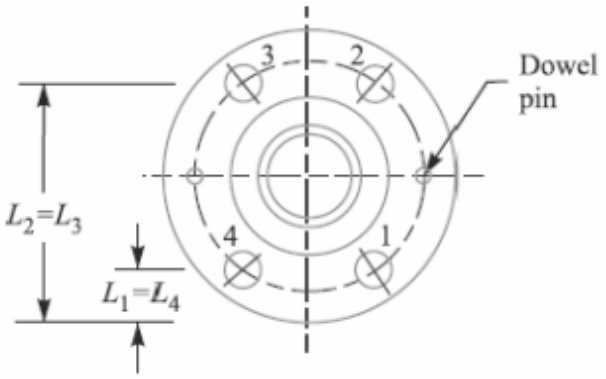


Fig.2.

INSTRUMENTATION AND CONTROL SYSTEMS

B.Tech. IV Year I Sem.	L	T/P/D	C
Course Code: ME702PC/AM731PE	4	0/0/0	4

Prerequisite: Mathematics-I, Thermodynamics, Basic of Electrical and electronic Engineering.

Course Objectives: Understanding the basic characteristic of a typical instrument. Identifying errors and their types that would occur in a instrument. Identifying properties used for evaluating the thermal systems. The concept of transducer and Various types and their characters.

Course Outcome: To identify various elements and their purpose in typical instruments, to identify various errors that would occur in instruments. Analysis of errors so as to determine correction factors for each an instrument. To understand static and dynamic characteristics of instrument and should be able to determine loading response time. For given range of displacement should be able to specify transducer, it accurate and loading time of that transducer.

UNIT – I

Definition – Basic principles of measurement – Measurement systems, generalized configuration and functional description of measuring instruments – examples. Static and Dynamic performance characteristics – sources of errors, Classification and elimination of errors.

Measurement of Displacement: Theory and construction of various transducers to measure displacement – Piezo electric, Inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures.

UNIT – II

Measurement of Temperature: Various Principles of measurement-Classification: Expansion Type: Bimetallic Strip- Liquid in glass Thermometer; Electrical Resistance Type: Thermistor, Thermocouple, RTD; Radiation Pyrometry: Optical Pyrometer; Changes in Chemical Phase: Fusible Indicators and Liquid crystals.

Measurement of Pressure: Different principles used- Classification: Manometers, Dead weight pressure gauge. Tester (Piston gauge), Bourdon pressure gauges, Bulk modulus pressure gauges Bellows – Diaphragm gauges. Low pressure measurement – Thermal conductivity gauges, ionization pressure gauges, Mcleod pressure gauge.

UNIT – III

Measurement of Level: Direct methods – Indirect methods – Capacitive, Radioactive, Ultrasonic, Magnetic, Cryogenic Fuel level indicators – Bubbler level indicators.

Flow measurement: Rotameter, magnetic, Ultrasonic, Turbine flow meter, Hot – wire anemometer, Laser Doppler Anemometer (LDA).

Measurement of Speed : Mechanical Tachometers, Electrical tachometers, Non- contact type-Stroboscope

Measurement of Acceleration and Vibration: Different simple instruments – Principles of Seismic instruments – Vibrometer and accelerometer using this principle- Piezo electric accelerometer.

UNIT – IV

Stress-Strain measurements : Various types of stress and strain measurements –Selection and installation of metallic strain gauges- electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains – Temperature compensation techniques, Use of strain gauges for measuring torque, Strain gauge Rosettes.

Measurement of Humidity: Moisture content of gases, Sling Psychrometer, Absorption Psychrometer, Dew point meter.

Measurement of Force, Torque and Power- Elastic force meters, load cells, Torsion meters, Dynamometers.

UNIT – V

Elements of Control Systems:

Introduction, Importance – Classification – Open and closed systems- Servomechanisms – Examples with block diagrams – Temperature, speed and position control systems- Transfer functions- First and Second order mechanical systems

TEXT BOOKS:

1. Principles of Industrial Instrumentation and Control Systems /Alavala / Cengage
2. Instrumentation, Measurement and Analysis/ B.C.Nakra and K.K.Choudhary/ Mc Graw Hill.

REFERENCE BOOKS:

1. Process Control Instrumentation Technology/ Curtis D. Johnson / Person
2. Mechanical Measurements / Sirohi and Radhakrishna / New Age International

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ANNAMACHARYA INSTITUTE OF TECHNOLOGY & SCIENCES
DEPARTMENT OF MECHANICAL ENGINEERING
LESSON PLAN

B.Tech IV Year I Semester **Academic year: 2019-2020**
Name of the staff member : **C SUBBARAYADU**
Name of the subject **INSTRUMENTATION AND CONTROL SYSTEMS**

UNIT-I: Introduction and Measurement of Displacement

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Basic principles of measurement, Measurement systems	3	
2			Static and Dynamic performance characteristics	2	
3			Classification and elimination of errors	2	
4			Theory of various transducers to measure displacement	2	
5			Piezo electric, Inductive, capacitance, resistance	3	
6			Photo electric transducers, Calibration procedures	3	
			TOTAL CLASSES	**15**	

UNIT-II :Measurement of Temperature and Pressure

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Bimetallic Strip- Liquid in glass Thermometer	4	
2			Thermistor, Thermocouple, RTD; Radiation Pyrometry	2	
3			Changes in Chemical Phase: Fusible Indicators and Liquid crystals	2	
4			Classification, Manometers, Dead weight pressure gauge.	2	
5			Bourdon pressure, Bulk modulus , Bellows, Diaphragm g	2	
6			ionization pressure gauges, Mcleod pressure gauge.	3	
			TOTAL CLASSES	**15**	

UNIT-III : Measurement of Level and Flow measurement.

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Capacitive, Radioactive, Ultrasonic, Magnetic level indica	5	
2			Rotameter, magnetic, Ultrasonic, Turbine flow meter,anem	5	
3			Mechanical , Electrical tachometers, Non-contact type Str	4	
4			Principles of Seismic instruments, Vibrometer and acceler	6	
			TOTAL CLASSES	**20**	

UNIT-IV :Stress-Strain measurements, Measurement of Humidity,Force, Torque

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Principal :

Staff Sign.. H.O.D.

LESSON PLAN

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Various types of stress and strain measurements .	4	
2			Temperature compensation techniques, Use of strain gaug	3	
3			Moisture content of gases, Absorption Psychrometer, Dev	4	
4			Elastic force meters, load cells	4	
5			Torsionmeters, Dynamometers	5	
TOTAL CLASSES				20	

UNIT-V : Elements of Control Systems

S.No	Date	Hour	Topic	No of periods required	REMARKS
1			Classification, Open and closed systems, Servomechanisr	3	
2			Examples with block diagrams, Temperature, speed and p	4	
3			Transfer functions	4	
4			First and Second order mechanical systems	3	
TOTAL CLASSES				14	

C. Subhramanyam
FACULTY

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COURSE PLAN

Staff Name : C. Subbarayudu Department : Mech

Class : B.Tech Subject : ICA Semester : I Branch : Mech Section : - Year : 4/5

ANNAMACHARYA INSTITUTE OF TECHNOLOGY & SCIENCES
DEPARTMENT OF MECHANICAL ENGINEERING
COURSE PLAN

B.Tech IV Year I-Semester **Academic year:2019-20**

Name of the staff member : **C SUBBARAYADU**

Name of the subject : **INSTRUMENTATION AND CONTROL SYSTEMS**

S.NO.	UNIT NO.	UNIT NAME	NO OF PERIODS REQUIRED	REMARKS
1	I	Introduction and Measurement of Displacement	15	
2	II	Measurement of Temperature and Pressure	15	
3	III	Measurement of Level and Flow measurement.	20	
4	IV	Stress-Strain measurements, Measurement of Humidity,Force	20	
5	V	Elements of Control Systems	14	
		TOTAL CLASSES	84	

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TOTAL

Set.1

1. What is LVDT? Explain its advantages, disadvantages and applications

2. Explain strain gauge accelerometer and capacitance accelerometer in detail?

3. Explain piezo resistive strain gauges and its advantages?

4. Explain any one purge system to measure liquid level.

Set.2

1. Explain any one float operated liquid level gauges

2. List any four mechanical tachometers used for measuring angular velocity and briefly explain them with suitable exams.

3. Explain any one type of electrical tachometer

4. Explain strain gauge accelerometer in detail

Set.3.

1.Explain the piezo electric transducer for displacement measurement and advantage's and application and limitations.

2.Explain and draw generalized measurement system and explain elements

3.State law of thermo couple .how are the laws useful in construction of thermo couple thermo meter

4.write manometer types and Explain any two types

Set.4.

1 Explain U-tube manometer andadvantage's and application and limitations

2 Explain and draw generalized measurement system and explain elements

3 Explain the piezo electric transducer for displacement measurement and advantage's and application and limitations

4 Explain bourdon gauge with neat sketch and write advantages and limitations

Instrumentation and control systems

1. Optical radiations involve _____

a) optoelectric devices b) biological devices

c) Mechanical devices d) chemical devices

2. Photoelectric transducers consist of _____

a) 1 transducer b) 3 transducers

c) 5 transducers d) 10 transducers

3. Photoconductive transducers produce output _____

a) due to change in inductance b) due to change in light

c) due to change in resistance d) due to change in temperature

4. Which of the following are nuclear radiations?

a) Beta b) Alpha

c) Gamma d) All of the mentioned

5. Which of the following is correct for the ionization transducer?

a) Grid current decrease constantly b) Grid current Increases constantly

c) Grid current is made constant d) None of the mentioned

6. Cold cathode ionization vacuum gauges are more accurate than hot cathode ionization vacuum gauges.

a) True b) False

7. Potentiometric resistance transducer measures _____

a) linear displacement b) rectangular displacement

c) square displacement d) triangular displacement

8. Resistance potentiometer consists of _____

a) capacitive element b) resistive element

c) inductive element d) no elements

9. Resistance transducer has _____

a) medium efficiency b) low efficiency

c) high efficiency d) zero efficiency

10. A capacitive transducer works on the principle of _____

a) inductance b) capacitance

c) resistance d) reluctance

11. Capacitance can be varied in _____

12. Capacitive pressure transducer uses distance of separation for sensing the _____

13. Piezoelectric transducer is used for measuring _____

14. RVDT means _____

15. Piezoelectric crystals produce _____

16. Thermistor is a contraction of _____

17. Thermistors have _____coefficient.

18. Thermistor has a resistance of _____

19. Thermistors are suited for _____measurements.

20. Change in resistance is measured using a _____

R15

Code No: 127EA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year I Semester Examinations, May/June - 2019
INSTRUMENTATION AND CONTROL SYSTEMS
(Common to ME, AME)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART- A

(25 Marks)

1.a)	What are the basic requirements of any measuring instrument?	[2]
b)	What is the influence of temperature on the design of measuring instruments?	[3]
c)	Give the classification of temperature measuring instruments.	[2]
d)	What are the limitations of diaphragm gauges?	[3]
e)	Differentiate between direct and indirect methods of level measurement.	[2]
f)	Explain the limitations of mechanical tachometers.	[3]
g)	Define gauge factor.	[2]
h)	What are the applications of load cells?	[3]
i)	Comment about the importance of control systems.	[2]
j)	Differentiate between closed and open loop control systems.	[3]

PART - B

(50 Marks)

2. Explain the dynamic performance characteristics of measuring instruments. [10]

OR

3. What are the various sources of error in measuring instruments? Suggest and explain the methods to minimize them. [10]

4.a) Explain the use of photo electric transducers for displacement measurement.
b) Discuss various principles of pressure measurement. [5+5]

OR

5.a) Explain various arrangements of manometers for pressure measurement.
b) Describe the arrangement of thermocouples for low temperature measurement. [5+5]

6.a) Give the constructional details and explain the working of a bubbler level indicator.
b) Explain the working principle of non-contact type tachometer. [5+5]

OR

7.a) Explain the applications and limitations of hot-wire anemometer.
b) Explain the principle of working of seismic instruments. [5+5]

8.a) Derive an equation for gauge factor.
b) Explain the working of absorption psychrometer. [5+5]

OR

9.a) What are strain gauge rosettes? Explain their applications.
b) Explain the working of torsion meter. [5+5]

10. Describe a servomechanism and explain its working. [10]

OR

11.a) List out the rules governing the construction of block diagram.
b) Explain the working of position control system. [5+5]

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Code No: 127EA **R15**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year I Semester Examinations, December - 2019
INSTRUMENTATION AND CONTROL SYSTEMS
(Common to ME, AME)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART- A

(25 Marks)

1.a)	What is the role variable conversion element of a measuring instruments.	[2]
b)	What is the importance of dynamic performance characteristics of measurement?	[3]
c)	Explain the working principle of thermal conductivity gauges.	[2]
d)	Explain the principle of working of pyrometer	[3]
e)	Differentiate between contact and Non-contact type tachometer.	[2]
f)	What are the mechanical methods to measure the vibrations and explain in brief?	[3]
g)	List out the salient features of a semi-conductor type strain gauge.	[2]
h)	Explain the applications of delta type strain gauge rosettes.	[3]
i)	List the several control devices with which you are familiar.	[2]
j)	Differentiate between open and closed loop control systems.	[3]

PART-B

(50 Marks)

2.a) Explain the various static characteristics of a measurement system in detail.
b) Define measurement and explain its significance in our daily life. [5+5]

OR

3.a) Discuss the various types of errors found in instruments.
b) What are the differences between accuracy and uncertainty? [5+5]

4. Discuss the following transducers with respect to their construction, working and characteristics.
a) Capacitance
b) Ionization [5+5]

OR

5.a) Explain the temperature measurement by thermocouples.
b) Explain the temperature measurement by resistance thermometers. [5+5]

6.a) List out the various equipment for measurement of flow. Explain anyone them in brief.
b) Distinguish between the direct and indirect modes of level measurement. Discuss in brief about the methods. [5+5]

OR

7.a) Explain the working of ultrasonic flow meters. Explain the different techniques used for measurement of flow velocity.
b) What are the advantages and disadvantages of these flow meters? [5+5]

8.a) Explain the construction and working of Water Vapour recorder with a sketch.
b) Explain mechanical torsion meter and derive its equation. [5+5]

OR

9.a) Explain the measurement of humidity by dew point meter in detail.
b) Discuss about torque measuring methods using dynamometers. [5+5]

10.a) What are the requirements of control system?
b) Describe the operation of a driver driving an automobile on the road and identify the components, input and output of the human system. [5+5]

OR

11.a) Classify the elements in control system. Explain about position control systems with neat sketch.
b) Write short notes on temperature control system. [5+5]

--ooOoo--

Instrumentation and Control

UNIT-1

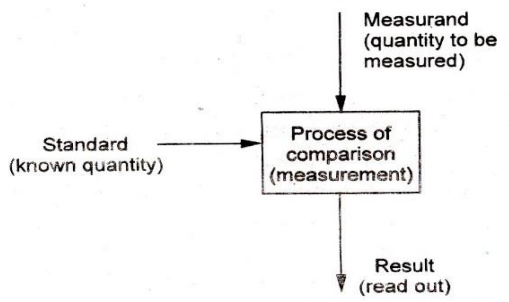
General Concept

Measurement:-

The old measurement is used to tell us length, weight and temperature are a change of these physical measurement is the result of an opinion formed by one (or) more observes about the relative size (or) intensity of some physical quantities.

Definition:

The word measurement is used to tell us the length, the weight, the temperature, the colour or a change in one of these physical entities of a material. Measurement provides us with means for describing the various physical and chemical parameters of materials in quantitative terms. For example 10 cm length of and object implies that the object is 10 times as large as 1 cm; the unit employed in expressing length.



Fundamental measuring process

These are two requirements which are to be satisfied to get good result from the measurement.

1. The standard must be accurately known and internationally accepted.
2. The apparatus and experimental procedure adopted for comparison must be provable.

Instrumentation:-

Definition:

The human senses cannot provide exact quantitative information about the knowledge of events occurring in our environments. The stringent requirements of precise and accurate measurements in the technological fields have, therefore, led to the development of mechanical aids called instruments.

Or

Definition: the technology of using instruments to measure and control physical and chemical properties of materials is called instrumentation.

In the measuring and controlling instruments are combined so that measurements provide impulses for remote automatic action, the result is called control system.

Uses:

-> study the function of different components and determine the cause of all functioning of the system, to formulate certain empirical relations.
-> to test a product on materials for quality control.
-> to discover effective components.
-> to develop new theories.
-> monitor a data in the interest of health and safety.

Ex:- fore casting weather it predicting in the earth case.

Methods of measurement:-

1. Direct and indirect measurement.
2. Primary and secondary & tertiary measurement.
3. Contact and non-contact type of measurement.

1. Direct and indirect measurement:

Measurement is a process of comparison of the physical quantity with a standard depending upon requirement and based upon the standard employed, these are the two basic methods of measurement.

Direct measurement:

The value of the physical parameter is determined by comparing it directly with different standards. The physical standards like mass, length and time are measured by direct measurement.

Indirect measurement:

The value of the physical parameter is more generally determined by indirect comparison with the secondary standards through calibration.

The measurement is convert into an analogous signal which subsequently process and fed to the end device at present the result of measurement.

2. Primary and secondary & tertiary measurement:

The complexity of an instrument system depending upon measurement being made and upon the accuracy level to which the measurement is needed. Based upon the complexity of the measurement systems, the measurement are generally grouped into three categories.

i. Primary
ii. Secondary
iii. Tertiary.

In the primary mode, the sought value of physical parameter is determined by comparing it directly with reference standards the required information is obtained to sense of side and touch.

Examples are:

a) Matching of two lengths is determining the length of a object with ruler.
b) Estimation the temperature difference between the components of the container by inserting fingers.
c) Use of bean balance measure masses.
d) Measurement of time by counting a number of strokes of a block.

Secondary and tertiary measurement are the indirect measurements involving one transmission are called secondary measurements and those involving two convergent are called tertiary measurements.

Ex:

The convergent of pressure into displacement by means of be allows and the convergent of force into displacement.

Pressure measurement by manometer and the temperature measurement by mercury in glass tube thermometer.

The measurement of static pressure by boundary tube pressure gauge is a typical example of tertiary measurement.

3. Contact and non-contact type of measurements:

Contact type:
Where the sensing element of measuring device as a contact with medium whose characteristics are being measured.

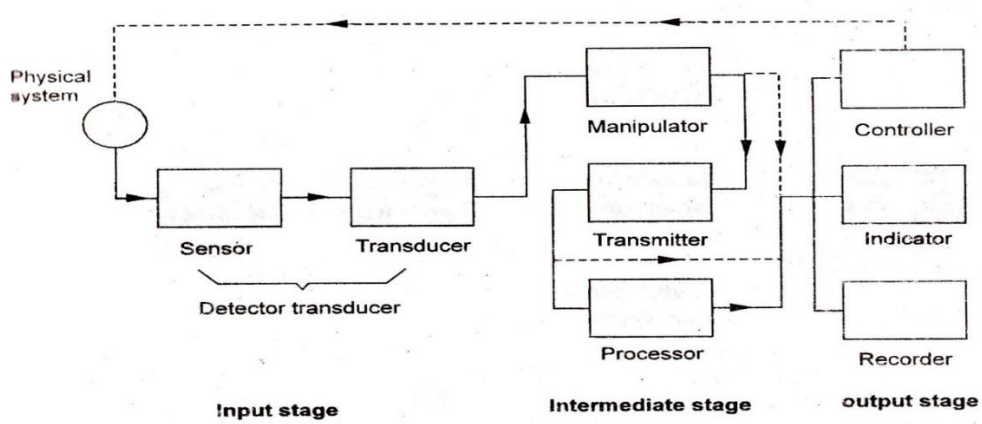
Non-contact type:
Where the sense doesn't communicate physically with the medium.

Ex:
The optical, radioactive and some of the electrical/electronic measurement belong to this category.

Objectives of instrumentation:-

1. The major objective of instrumentation is to measure and control the field parameters to increase safety and efficiency of the process.
2. To achieve good quality.
3. To achieve auto machine and automatic control of process there by reducing human.
4. To maintain the operation of the plan within the design exportations and to achieve good quantity product.

Generalised measurement system and its functional elements:-



Generalised measurement system

1) Primary sensing element.

2) Variable conversion (or) Transducer element.

3) Manipulation of element.

4) Data transmission element.

5) Data processing element.

6) Data presentation element.

The principal functions of an instrument is the acquisition of information by Sensing and perception, the process of that information and its final presentation to a Human observer. For the purpose of analysis and synthesis, the instrument s are considered as systems (or) assembly of inter connected components organised to perform a specified function. The different components are called elements.

1) PIMARY SENSING ELEMENT:

An element that is sensitive to the measured variable .The sensing element sense the condition , state (or) value of the process variable by extracting a small part of energy from the measurement and produces an output which is proportional to the input. Because of the energy expansion, the measured quantity is always disturb. Good instruments are designed to minimise this loading effect.

2) Variable conversion (or) transducer element:

An element that converts the signal from one physical for to Another without changing the information content of the signal.

Example:

- Bourdon tube and bellows which transfer pressure into displacement.
- Proving ring and other elastic members which converts force into displacement.
- Rack and Pinion: It converts rotary to linear and vice versa.
- Thermo couple which converts information about temperature difference to information in the form of E.M.F.

3) MANIPULATION ELEMENT:

It modifies the direct signal by amplification, filtering etc., so that a desired output is produced.

$$[\text{input}] \times \text{constant} = \text{Output}$$

4) DATA TRANSMISSION ELEMENT:

An element that transmits the signal from one location to another without changing the information content. Data may by transmitted over long distances (from one location to another) or short distances (from a test centre to a nearby computer).

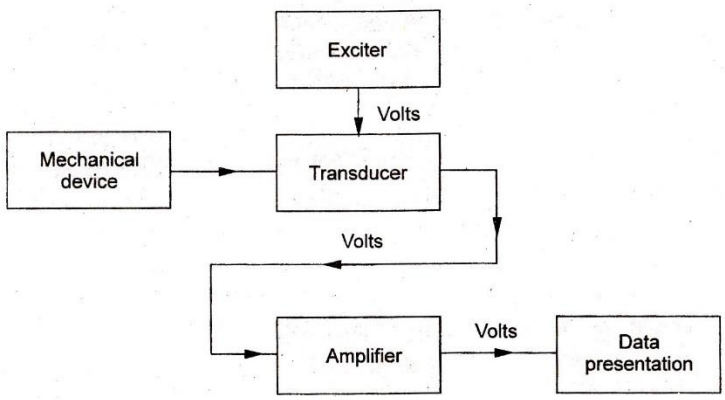
5) DATA PROCESSING ELEMENT:

An element that modifies data before it is displayed or finally recorded. Data processing may be used for such purposes as:

- ✓ Corrections to the measured physical variables to compensate for scaling, non-linearity, zero offset, temperature error etc.

- ✓ Covert the data into useful form, e.g., calculation of engine efficiency from speed, power input and torque developed.
- ✓ Collect information regarding average, statistical and logarithmic values.

6) DATA PRESANTION ELEMENT:



Electro-mechanical measurement system

An element that provides record or indication of the output from the data processing element. Ina measuring system using electrical instrumentation, an exciter and an amplifier are also incorporated into the circuit.

The display unit may be required to serve the following functions.

- ✓ transmitting
- ✓ Signalling
- ✓ Registering
- ✓ Indicating
- ✓ recording

The generalised measurement system is classified into 3 stages:

a) Input Stage

b) Intermediate Stage

i. Signal Amplifications

ii. Signal Filtration

iii. Signal Modification

iv. Data Transmission

c) Output Stage

a) Input Stage:

Input stage (Detector-transducer) which is acted upon by the input signal (a variable to be measured) such as length, pressure, temperature, angle etc. and which transforms this signal in some other physical form. When the dimensional units for the input and output signals are same, this functional element/stage is referred to as the transformer.

b) Intermediate Stage:

i. signal amplification to increase the power or amplitude of the signal without affecting its waveform. The output from the detector-transducer element' is generally too small to operate an indicator or a recorder and its amplification is necessary. Depending upon the type of transducer signal, the amplification device may be of mechanical, hydraulic/pneumatic, optical and electrical type.

ii. Signal filtration to extract the desired information from extraneous data. Signal filtration removes the unwanted noise signals that tend to obscure the transducer signal. Depending upon nature of the signal and situation, one may use mechanical, pneumatic or electrical filters.

iii. Signal modification to provide a digital signal from an analog signal or vice versa, or change the form of output from voltage to frequency or from voltage to current.

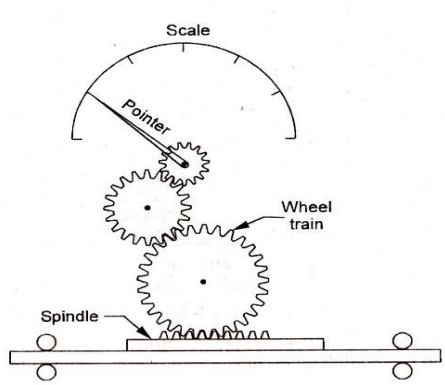
Iv. Data transmission to telemeter the data for remote reading and recording.

c) Output Stage:

which constitutes the data display record or control. The data presentation stage collects the output from the signal-conditioning element and presents the same to be read or seen and noted by the experimenter for analysis. This element may be of:-

- ✓ visual display type such as the height of liquid in a manometer or the position of pointer on a scale
- ✓ numerical readout on an electrical instrument
- ✓ Graphic record on some kind of paper chart or a magnetic tape.

Example: Dial indicator



Dial indicator

CLASSIFICATION OF INSTRUMENTS:-

1) Automatic and Manual instruments:

2) Self generating and power operated

3) Self contact and remote indicating instruments

4) Deflection and null type

5) Analog and digital types

6) Contact and no-contact type

1) Automatic and manual instruments:

The manual instruments require the services of an operator while the automatic types donot. For example, the temperature measurement by mercury-in-glass thermometer is automatic as the instrument indicates the temperature without requiring any manual assistance. However, the measurement of temperature by a resistance thermometer incorporating; Wheatstone brigde in its circuit is manual in operation as it needs an operator for obtaining the null position.

2) Self generating and power operated

Self-generated instruments are the output is supplied entirely by the input signal. The instrument does not require any out side power in performing its function

Example: mercury in glass thermometer, bourdon pressure gauge, pitot tube for measuring velocity

So instruments require same auxillary source of power such as compound air, electricity, hydraulic supply for these operations and hence are called externally powered instruments (or) passive instruments.

Example:

- L.V.D.T(Linear Variable Differential Transducer)
- Strain gauge load cell
- Resistance thermometer and the mister.
- Self contained remote indicator.

3) Self contact and remote indicating instruments:

The different elements of a self-contained instrument are contained in one physical assembly. In a remote indicating instrument, the primary sensing element may be located at a sufficiently long distance from the secondary indicating element. In the modern instrumentation technology, there is a trend to instalremote indicating instruments where the important indications can be displayed in the central control rooms.

4) Deflection and null output instruments:

In null-type instruments, the physical effect caused by the quantity being measured is nullified (deflection maintained at zero) by generating an equivalent opposing effect. The equivalent null causing effect then provides a measure of the unknown quantity. A deflection type instrument is that in which the physical effect generated by the measuring quantity (measurand) is noted and correlated to the measurand.

5) Analog and digital instruments:

The signals of an analog unit vary in a continuous fashion and can take on infinite number of values in a given range. Wrist watch speedometer of an automobile, fuel gauge, ammeters and voltmeters are examples of analog instruments.

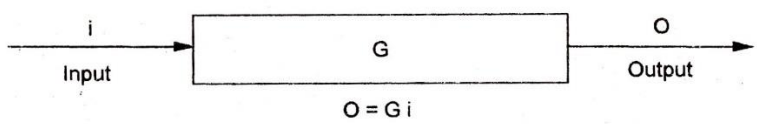
Instruments basically perform two functions:

(i) Collection of data and

(ii) control of plant and process

Accordingly based upon the service rendered, the instruments may also be classified as indicating instruments, recording instruments and controlling instruments.

INPUT, OUTPUT CONFIGURATION OF A MEASURING INSTRUMENT:-



Input-output relation of a measurement system

An instrument performs an operation on an input quantity (measurement/designed variable) to provide an output called the measurements. The input is denoted by "i" and the output is denoted by "o". According to the performance of the instrument can be stated in terms of an operational transfer function(G).The input and output relationship is characterised by the operation 'G' such that

$$o=G\,i$$

The various inputs to a measurement system can be classified into-three categories:

i) Desired input:

A quantity that the instrument is specifically intended to measure. The desired input i_D produces an output component according to an input-output relation symbolised by G_D; here G_D represents the mathematical operation necessary to obtain the output from the input.

ME712PE/MT821PE: AUTOMATION IN MANUFACTURING (PE – II)

B.Tech. IV Year I Sem.

L	T	P	C
3	0	0	3

UNIT - I

Introduction: Types and strategies of automation, pneumatic and hydraulic components circuits, Automation in machine tools. Mechanical feeding and tool changing and machine tool control transfer the automation.

UNIT - II

Automated flow lines: Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration.

Analysis of Automated flow lines: General terminology and analysis of transfer lines without and withbuffer storage, partial automation, implementation of automated flow lines.

UNIT - III

Assembly system and line balancing: Assembly process and systems assembly line, line balancingmethods, ways of improving line balance, flexible assembly lines.

UNIT - IV

Automated material handling: Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems. Automated storage systems, Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

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UNIT -V

Fundamentals of Industrial controls: Review of control theory, logic controls, sensors and actuators, Data communication and LAN in Manufacturing.

Business process Re-engineering: Introduction to BPE logistics, ERP, Software configuration of BPE.

TEXT BOOK:

1. Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover 3e./PE/PHI, 2009.

REFERENCE BOOKS:

1. Computer Aided Manufacturing, Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang, Pearson, 2009.
2. Automation by W. Buekinsham.

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Department Of Mechanical Engineering

Web References/Self Learning Resources List

Course Name : AIM
Class : IV year- I Semester (2021-2022)

PowerPoint Presentations

Topic	Presentation Location/File Name
AIM (All 5 Units)	SPOORTHI_AIM_PPTS UNIT WISE

Video Lectures with Web References

Topic	Video Location/File Name
Introduction to AIM	https://www.youtube.com/watch?v=v-3TmN4HhLc
Automated flow lines	https://www.youtube.com/watch?v=r-3kkxX4GEc
Line Balancing	https://www.youtube.com/watch?v=lDvcVDmcgA8

Suggested MOOC References

MOOC Site Name	Course Link
NPTEL	https://nptel.ac.in/courses/112103293
NPTEL	https://nptel.ac.in/courses/112103293
NPTEL	https://nptel.ac.in/courses/112103293

Faculty Signature

PRINCIPAL
Annamacharya Institute of Technology & Sciences

Department of Mechnaical Engineering

Lecture Plan

S. No	Topic	Expected Date of Completi	Actual Date of Completi	Book/Page No.	CO's	Blooms Taxonomy	Teaching Learning Process
	UNIT-I						
1	Introduction of automation	7-9-2021	7-9-2021	T1	C412.1	Understand	Board Lecture
2	Types of automation	7-9-2021	7-9-2021	T2	C412.1	Understand	PPT
13	Types of automation	8-9-2021	8-9-2021	T1	C412.1	Understand	Board Lecture
4	Strategies of automation	8-9-2021	8-9-2021	T1	C412.1	Remember	Board Lecture
3	Strategies of automation	14-9-2021	14-9-2021	T1&R1	C412.1	Understand	PPT
4	Principles of automation	15-9-2021	15-9-2021	T1	C412.1	Understand	Board Lecture
5	Pneumatic components circuits	15-9-2021	15-9-2021	T1	C412.1	Remember	Board Lecture
6	Hydraulic components circuits	21-9-2021	21-9-2021	T1	C412.1	Understand	Board Lecture
7	Automation in machine tools	22-9-2021	22-9-2021	T1	C412.1	Remember	Board Lecture
8	Mechanical feeding and tool changing	22-9-2021	22-9-2021	T1&R1	C412.1	Understand	Board Lecture
9	automation	29-9-2021	29-9-2021	T1	C412.1	Understand	Board Lecture
10	Machine tool control transfer the automation	29-9-2021	29-9-2021	T1&R1	C412.1	Remember	Board Lecture
11	Machine tool control transfer the automation	30-9-2021	30-9-2021	T1	C412.1	Understand	Board Lecture
12	Revision	30-9-2021	30-9-2021	T1	C412.1	Understand	Board Lecture
	UNIT-II						
1	Introduction of Automated flow lines	1-10-2021	1-10-2021	T1	C412.2	Remember	Board Lecture
2	Importance Automated flow lines	5-10-2021	5-10-2021	T1	C412.2	Understand	Board Lecture
3	Assembly System Configurations	7-10-2021	7-10-2021	T1&R1	C412.2	Remember	Board Lecture
4	Methods of Automated flow lines	7-10-2021	7-10-2021	T1	C412.2	Understand	PPT
5	Methods of Automated flow lines	8-10-2021	8-10-2021	T1	C412.2	Understand	Board Lecture
6	Methods of work part transport lines	11-10-2021	11-10-2021	T1	C412.2	Remember	Board Lecture
7	Methods of work part transport lines	19-10-2021	19-10-2021	T1	C412.2	Remember	Board Lecture
8	buffer storage	20-10-2021	20-10-2021	T1	C412.2	Understand	Board Lecture
9	Methods of work part transport transfer with buffer storage control	26-10-2021	26-10-2021	T1	C412.2	Understand	Board Lecture
10	Methods of work part transport transfer with buffer storage control	29-10-2021	29-10-2021	T1&R1	C412.2	Remember	Board Lecture
11	Methods of work part transport transfer without buffer storage control	27-10-2021	27-10-2021	T1	C412.2	Remember	Board Lecture

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12	Methods of work part transport transfer without buffer storage control	2-11-2021	2-11-2021	T1	C412.2	Understand	Board Lecture
13	Design and fabrication consideration	5-11-2021	5-11-2021	T1	C412.2	Create	Board Lecture
14	Analysis of Automated flow lines	9-11-2021	9-11-2021	T1&R1	C412.2	Apply	Board Lecture
15	General terminology	11-11-2021	11-11-2021	T1	C412.2	Remember	Board Lecture
16	Analysis of transfer lines with buffer storage	11-11-2021	11-11-2021	T1	C412.2	Apply	Board Lecture
17	Analysis of transfer lines without buffer storage	12-11-2021	12-11-2021	T1&R1	C412.2	Apply	Board Lecture
18	Partial automation	15-11-2021	15-11-2021	T1	C412.2	Understand	Board Lecture
19	Implementation of automated flow lines.	18-11-2021	18-11-2021	T1&R1	C412.2	Remember	Board Lecture
20	Revision	18-11-2021	18-11-2021				
	UNIT-III						
1	Assembly system	23-11-2021	23-11-2021	T1	C412.3	Remember	Board Lecture
2	Types of Assembly system	23-11-2021	23-11-2021	T1	C412.3	Remember	Board Lecture
3	Assembly line	23-11-2021	23-11-2021	T1&R1	C412.3	Understand	Board Lecture
4	Types of Assembly line	26-11-2021	26-11-2021	T1	C412.3	Understand	PPT
5	Types of Assembly line	26-11-2021	26-11-2021	T1	C412.3	Understand	Board Lectur
6	Line balancing methods	26-11-2021	26-11-2021	T1	C412.3	Apply	Board Lecture
7	Line balancing methods	30-11-2021	30-11-2021	T1&R1	C412.3	Apply	Board Lecture
8	Line balancing problems-LCR	30-11-2021	30-11-2021	T1	C412.3	Apply	Board Lecture
9	Line balancing problems-LCR	30-11-2021	30-11-2021	T1	C412.3	Apply	Board Lecture
10	Line balancing problems-KWM	1-12-2021	3-12-2021	T1	C412.3	Apply	Board Lecture
11	Line balancing problems-KWM	3-12-2021	3-12-2021	T1	C412.3	Apply	Board Lecture
12	Line balancing problems-RPW	3-12-2021	3-12-2021	T1&R1	C412.3	Apply	Board Lecture
13	Line balancing problems-RPW	10-12-2021	10-12-2021	T1	C412.3	Remember	Board Lecture
14	Ways of improving line balance	10-12-2021	10-12-2021	T1	C412.3	Understand	Board Lecture
15	Flexible assembly lines	10-12-2021	10-12-2021	T1	C412.3	Understand	Board Lecture
16	Flexible assembly lines	14-12-2021	14-12-2021	T1&R1	C412.3	Remember	Board Lecture
17	Revision	14-12-2021	14-12-2021				
	UNIT-IV						
1	Automated material handling	14-12-2021	14-12-2021	T1	C412.4	Understand	Board Lecture
2	Types of Materials Handling	14-12-2021	14-12-2021	T1	C412.4	Understand	Board Lecture
3	Types of Materials Handling	14-12-2021	14-12-2021	T1&R1	C412.4	Remember	Board Lecture
4	Principles of Material Handling	17-12-21	17-12-2021	T1	C412.4	Understand	Board Lecture
5	Analysis of material handling systems	17-12-2021	17-12-2021	T1	C412.4	Understand	Board Lecture
6	Design of material handling systems conveyor systems	17-12-2021	17-12-2021	T1	C412.4	Create	PPT
7	Automated guided vehicle systems.	21-12-2021	21-12-2021	T1&R1	C412.4	Remember	Board Lecture
8	Automated storage systems	21-12-2021	21-12-2021	T1	C412.4	Understand	Board Lecture
9	Automated storage systems	21-12-2021	21-12-2021	T1	C412.4	Understand	Board Lecture
10	Automatic storage/retrieval system	28-12-2021	28-12-2021	T1	C412.4	Remember	Board Lecture
11	Types of Automatic storage/retrieval	28-12-2021	28-12-2021	T1	C412.4	Understand	Board Lecture
12	work in process storage	28-12-2021	28-12-2021	T1&R1	C412.4	Understand	Board Lecture
13	Interfacing handling and storage with	30-12-2021	30-12-2021	T1	C412.4	Remember	Board Lecture
14	Revision	30-12-2021	30-12-2021	T1			
	UNIT-V						

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1	Fundamentals of Industrial controls	28-12-2021	28-12-2021	T1	C412.5	Remember	Board Lecture
2	Fundamentals of Industrial controls	28-12-2021	28-12-2021	T1	C412.5	Remember	Board Lecture
3	Review of control theory	30-12-2021	30-12-2021	T1&R1	C412.5	Remember	PPT
4	logic controls	30-12-2021	30-12-2021	T1	C412.5	Understand	Board Lecture
6	Sensors	30-12-2021	30-12-2021	T1	C412.5	Understand	Board Lecture
7	Actuators	6-1-2022	6-1-2022	T1&R1	C412.5	Understand	Board Lecture
8	Data communication	6-1-2022	6-1-2022	T1	C412.5	Remember	PPT
9	LAN in Manufacturing	7-1-2022	7-1-2022	T1	C412.5	Understand	Board Lecture
10	Business process Re-engineering	7-1-2022	7-1-2022	T1	C412.5	Understand	Board Lecture
11	Business process Re-engineering	7-1-2022	7-1-2022	T1	C412.5	Understand	PPT
12	Introduction to BPE logistics	7-1-2022	7-1-2022	T1&R1	C412.5	Understand	Board Lecture
13	ERP	18-1-2022	18-1-2022	T1	C412.5	Remember	Board Lecture
14	ERP	18-1-2022	18-1-2022	T1	C412.5	Remember	Board Lecture
15	Software configuration of BPE	18-1-2022	18-1-2022	T1&R1	C412.5	Understand	Board Lecture
16	Software configuration of BPE	18-1-2022	18-1-2022	T1	C412.5	Understand	Board Lecture
17	Revision						

Total No. of Lectures = 64

Text Books:

Automation, Production Systems and Computer

T1. Integrated Manufacturing: M.P. Groover
3e./PE/PHI, 2009.

Reference Books:

R1.Computer Aided Manufacturing, Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang,Pearson, 2009

R2.Automation by W. Buekinsham.

Web References:

W1. https://nptel.ac.in/courses

W2.quality gate.co.in

W3. www.wikipidea.org

W4. https://www.youtube.com/watch

W5. mit opencourseware.in

W6.www.lecture notes.co.in

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Department of Mechanical Engineering

Unit Wise Short and Long Answer

S. No.	Question
	UNIT - 1
1	Define automation. Classify different types of automation and discuss the important reasons for automation.
2	Draw the simple block diagram of hydraulic circuit and discuss it.
3	Discuss various types of automation strategies mentioning their importance.
4	Enumerate different components in hydraulic system.
5	Differentiate programmable and flexible automation.
6	What strategies are framed for automation?
7	What are the various situations where automation is preferred over manual labor?
8	Describe the pneumatic components used in an automation system
9	How mechanical feeding is replaced by automation?
	UNIT – II
1	Explain the reasons for including a storage buffer in automated production lines.
2	What are the various system configurations developed in automatic production lines
3	With neat diagrams explain the functioning of various types of Transfer Mechanisms.
4	Explain about the mechanical buffer storage control function
5	What are the methods employed for workpart transport?
6	What are the functions of storage buffer?
7	What are the three configurations of automated flow lines?
8	What is instantaneous control and memory control in control functions?
	UNIT – III
1.	Explain the following terms in line balancing

	i) Total work content ii) Work station process time
2	Discuss any four methods that should be considered by the designer of a flow line for improving the efficiency of the assembly line.
3	What are the various assembly systems used in practice and explain the advantages of manual single-stage assembly?
4	Differentiate between Kilbridge and Wester's method and Ranked positional weights Method of line balancing.
5	Explain largest candidate rule (LCR) with an example.
6	Write short note on flexible assembly lines
7	Give the importance of precedence diagram in line balancing
8	Describe the Kilbridge and Wester method. What are the ways of improving line balance?

	UNIT – IV
1	Explain the various sources of variability in adaptive control machining?
2	What is an AGV? Classify different types of AGV's
3	Explain how adaptive control is differentiated from conventional feedback control?
4	What are the situations where adaptive control can be beneficially applied?
5	What are the various material handling system used?
6	What are the types of AGVS's used in present automated system? What is an interfacing handling?
7	What are the types of AS/RS systems? Explain any two of them.
8	What are the design aspects considered in an AS/RS system?
9	List out different types of material handling equipment.

	UNIT – V
1	Define and discuss briefly about ERP.

2	What is 3D printing? Explain its role in rapid prototyping?
3	Describe with neat sketch, the working of machine vision.
4	What are the types of CMM? Explain any two of them.
5	What are the two categories of inspection?
6	What are the two categories of inspection?
8	What do you know about Off-line Inspection Methods?
9	What is automated inspection? Discuss its procedure.

UNIT WISE OBJECTIVE TYPE QUESTION BANK

(QUESTION BANK)

MULTIPLE CHOICE QUESTIONS

1. In USA "S" Stands for ( )
a) Start the process
b) Solve the process
c) Simplify the process
d) All the above

2. Fixed automation are ( )
a) Low production rates
b) High production rates
c) Low production rates
d) None of the above

3. Closed loop systems are also called as? ( )
a) Process control systems
b) Feedback control systems
c) Actuator control systems
d) None of the above

4. Automated system is ( )
a) Manually operated
b) Machine operated
c) Semi machine operated
d) Both

5. Varieties of product can be manufactured by ( )
a) Programmable automation system
b) Fixed automation system
c) Flexible automation system
d) Both (a) or (c)

6. Input /output analysis are used for? ( )
a. Operations are linked together
b. Industries are linked together
c. Workstations are linked together
d. All the above

7. Automation migration strategy is used for? ( )
a. Introduction of new product
b. Introduction of new process
c. Introduction of new procedure
d. None of the above

8. CIM means ( )
A. Computer integrated machine
B. Computer integrated manufacturing
C. Computer initiate manufacturing
D. Computer integrated method

9. Actuators are ( )
a. Which provides feedback

b. Which is controlled in the loop
c. Which does the work
d. None of the above

10. Automation integrated production uses ( )
A. single station manned cells
B. multi station manned cells
C. single station automated cells
D. multi station automated cells

FILL IN THE BLANKS

1. MPS stands for _____
2. Control systems are 2types they are _____ and _____
3. Basic elements of automated systems are _____
4. Simply the process principle is used to _____
5. PLC stands for _____
6. Industrial robots are example of _____
7. Online inspection strategy is used for _____
8. Two examples of automated manufacturing system _____
9. Inventory control means _____
10. Aim of production system is_____ _____

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Code No: 138AT

R16

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year II Semester Examinations, September - 2020
AUTOMATION IN MANUFACTURING
(Common to ME, MCT)

Time: 2 Hours

Max. Marks: 75

Answer any Five Questions
All Questions Carry Equal Marks

1.a) Define automation. Classify different types of automation and discuss the important reasons for automation
b) Draw the simple block diagram of hydraulic circuit and discuss it briefly. [8+7]

2.a) Discuss various types of automation strategies mentioning their importance.
b) Differentiate between flexible automation and fixed automation and mention their advantages and laminations. [8+7]

3.a) Explain the reasons for including a storage buffer in an automated production lines.
b) What are the various system configurations developed in automatic production lines? [7+8]

4.a) With neat diagrams explain the functioning of various types of Transfer Mechanisms.
b) Explain about the mechanical buffer storage control function. [8+7]

5.a) Explain the following terms in line balancing
i) Total work content ii) Work station process time
b) Discuss any four methods that should be considered by the designer of a flow line for improving the efficiency of the assembly line. [8+7]

6.a) What are the various assembly systems used in practice and explain the advantages of manual single-stage assembly?
b) Differentiate between Kilbridge and Wester's method and Ranked positional weights method of line balancing. [8+7]

7.a) Explain the various sources of variability in adaptive control machining?
b) What is an AGV? Classify different types of AGV's. [8+7]

8.a) Define and discuss briefly about ERP.
b) What is 3D printing? Explain its role in rapid prototyping? [8+7]

—ooOoo—

Code No: 128AP **R15**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year II Semester Examinations, July - 2019
AUTOMATION IN MANUFACTURING
(Mechanical Engineering (Mechatronics))

Time: 3 hours Max. Marks: 75

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A
(25 Marks)

1.a) What are the reasons for automation? [2]
b) What are the components used in hydraulic circuits with automation? [3]
c) Discuss the term 'Blocking of stations' used in the automated flow lines. [2]
d) What are the advantages of the continuous transfer mechanisms? [3]
e) Define the term 'Total work content'. [2]
f) Explain the term 'precedence constraint' in line balancing. [3]
g) Write a short note on storage structure of an AS/RS. [2]
h) What are the problems encountered in the control of AS/RS operation. [3]
i) What are the advantages of hydraulic actuation systems? [2]
j) Compare open and closed loop control systems. [3]

PART - B
(50 Marks)

2.a) What are the different types automation? Discuss them briefly.
b) What are the important mechanical feeding devices used in automated systems? Discuss them briefly. [5+5]

OR

3.a) Discuss the following automation strategies:
i. Combined Operations ii. On-line inspection
iii. Plant Operation Control iv. Process Control and Optimization.
b) Discuss the reasons for implementation of automated systems in the manufacturing industries. [5+5]

4.a) Explain the differences between intermittent transfer mechanism and power-and-free transfer mechanism.
b) What is 'partial automation' and what are the reasons for the existence of partially automated production lines in the shop floors? [5+5]

OR

5.a) Define the following terms used in automated flow lines and write the mathematical expressions for each term:
i. Production Time
ii. Theoretical Production Rate
b) Briefly discuss on the efficiency of an automated flow lines with storage buffer. [5+5]

Department of Mechanical Engineering

Assignment 1

Course Name : AIM (C412)

Class : B.Tech (MECH) IV year, I Sem (2021-2022)

Date of Assignment:

Date of Submission:

1. Define automation. Classify different types of automation and discuss the important reasons for automation.
2. Draw the simple block diagram of hydraulic circuit and discuss it.
3. Discuss various types of automation strategies mentioning their importance. \
4. Differentiate between flexible automation and fixed automation and mention their advantages and laminations

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Department of Mechanical Engineering

Assignment 2

Course Name : AIM (C412)

Class : B.Tech (MECH) IV year, I Sem (2021-2022)

Date of Assignment:

Date of Submission:

1. Explain the reasons for including a storage buffer in automated production lines.
2. What are the various system configurations developed in automatic production lines.
3. With neat diagrams explain the functioning of various types of Transfer Mechanisms.
4. Explain about the mechanical buffer storage control function

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Department of Mechanical Engineering

Assignment 3

Course Name : AIM (C412)

Class : B.Tech (MECH) IV year, I Sem (2021-2022)

Date of Assignment:

Date of Submission:

1. Explain the following terms in line balancing
   i) Total work content ii) Work station process time
2. Discuss any four methods that should be considered by the designer of a flow line for improving the efficiency of the assembly line.
3. What are the various assembly systems used in practice and explain the advantages of manual single-stage assembly?
4. Differentiate between Kilbridge and Wester's method and Ranked positional weights Method of line balancing.

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Department of Mechanical Engineering

Assignment 4

Course Name : AIM (C412)

Class : B.Tech (MECH) IV year, I Sem (2021-2022)

Date of Assignment:

Date of Submission:

1. Explain the various sources of variability in adaptive control machining?
2. What is an AGV? Classify different types of AGV's.
3. Explain how adaptive control is differentiated from conventional feedback control?
4. What are the situations where adaptive control can be beneficially applied?

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Department of Mechanical Engineering

Assignment 5

Course Name : AIM (C412)

Class : B.Tech (MECH) IV year, I Sem (2021-2022)

Date of Assignment:

Date of Submission:

1. Define and discuss briefly about ERP.
2. What is 3D printing? Explain its role in rapid prototyping?
3. Describe with neat sketch, the working of machine vision.
4. What are the types of CMM? Explain any two of them.

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Automation In Manufacturing

UNIT-I

→ Introduction to Automation in Manufacturing:-

1) An Automation system is one in which a process is performed by a machine without the direct participation of a human worker. Automation is implemented by using a program of instructions combined with a control system that executes the instructions.

2) In other words Automation can also be defined as a technology concerned with the application of electronic, mechanical & computer based systems to operate & control the production.

Examples:- CNC Machines, Automated guided vehicles, robots etc.

3) power is required to drive the process & to operate the program & control system.

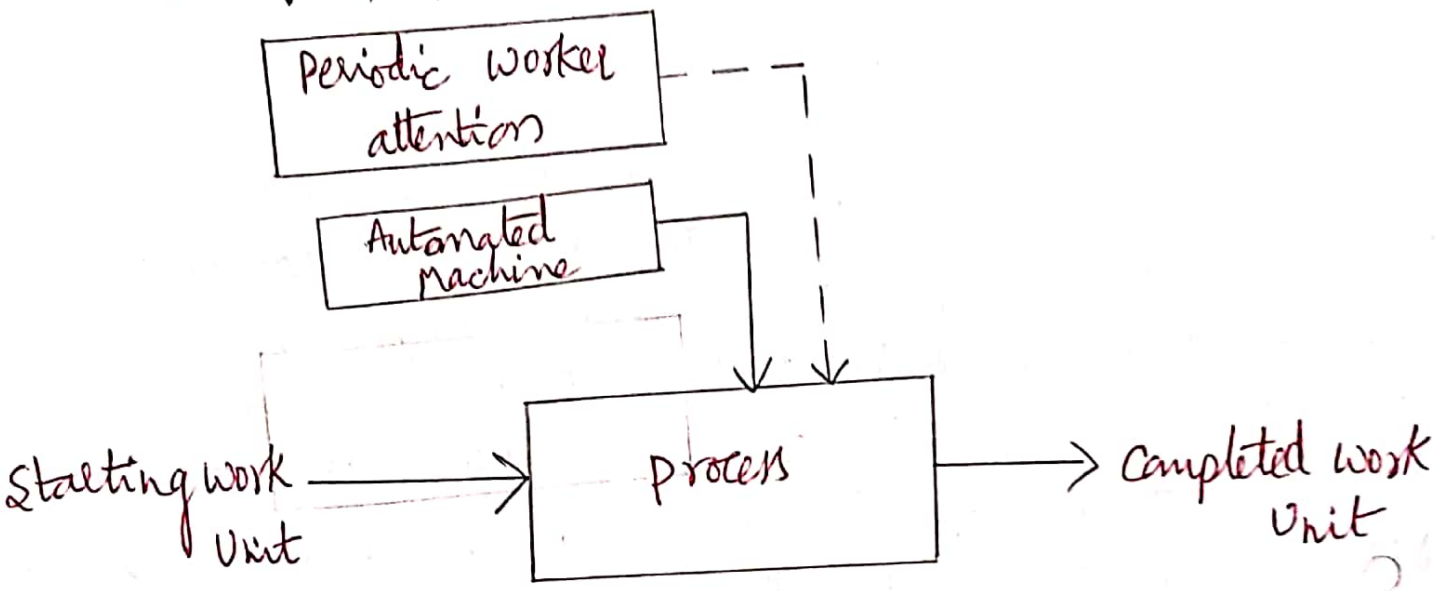
→ Levels of Automation:- Two level of Automateans they are

i) Semi-automated system:- It performs a portion of the work cycle under some form of program control & a human worker tends to the machine for the remainder of the cycle, by loading & unloading it (or) it performing some other task each cycle (or) In simple words Semi-Automated system can be defined as a process or a procedure that is performed by the combined activities of Man & M/C with both human & machine (M/C) steps typically orchestrated by a centralized computer controller.

ii) fully Automated system:- This is different from semi-automated system. It operates for extended periods of time with no human attention (or) In simple words fully automated system can be defined as they are fully automated & require no human presence on-site An Automatic factory is a place where raw materials enter & finished products

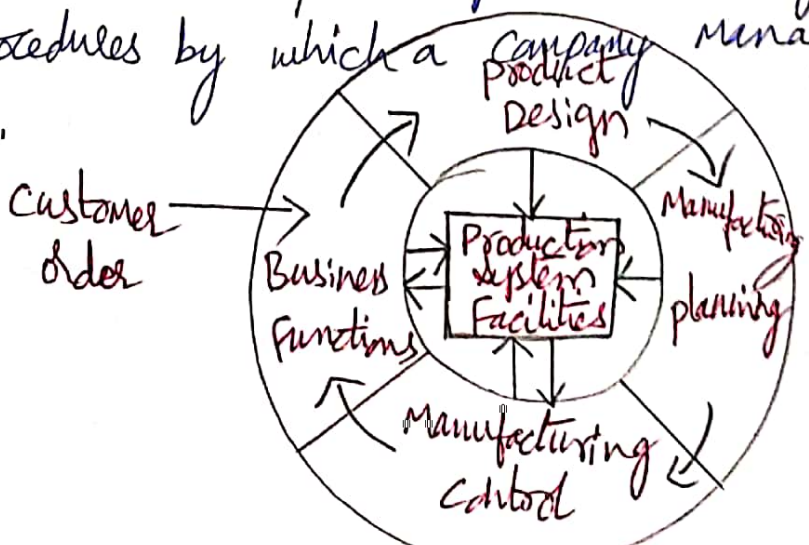
base with little (or) no human intervention.

→ Schematic Diagram of Automated systems :-



→ Aim of production system :- The aim of production system is provide goods & services for mankind in ① In right quantities ② At the appropriate place ③ At the desired time ④ with the required quantity ⑤ At a resonable cost ⑥ maintain good quality.

→ Manufacturing support systems :- To operate facilities effiently, a company must organize itself to design the processes & equipment, plan & control the production orders & satisfy production quality requirements. These functions are accomplished by manufacturing support systems - people & procedures by which a company manages its production operations.



Information processing cycle in a typical manufacturing firm

→ Involves a cycle of information-processing activities that consists of 4 functions:- ②

*Included in this category are

1) Business functions:- Sales & Marketing, order entry, sales forecasting, cost accounting & customer billing..

The Business functions are the principal means of communicating with the customer. They are therefore the beginning & the end of the information processing cycle

In order to produce a product typically originates from customer & proceeds into the company through sales & marketing department of the firm. The product order will be in following forms 1) an order to manufacture an item to the customer specifications 2) a customer order to buy one or more of the manufacturer's proprietary products (or) 3) an internal company order based on a forecast of future demand for proprietary product.

2) Product Design:-

If the product is to be manufactured to customer design, the design will have been provided by the customer. The manufacturer's product design department will not be involved. If the product is to be produced to customer specifications, the manufacturer's product design department may be contracted to do the design work for the product as well as to manufacture it.

If the product is proprietary, the manufacturing firm is responsible for its development & design. The cycle of events that initiates a new product design often originates in the sales & marketing department.

*This department of the firm that are organised to accomplish might include i) research & development 2) design engineering & perhaps a prototype shop.

3) Manufacturing planning:- The information & documentation that constitute the product design flows into the manufacturing planning function. The information processing activities in " " includes 1) process planning 2) Master scheduling 3) requirement planning 4) capacity planning

1) process planning:- consists of determining the sequence of individual processing & assembly operations needed to produce the part. The manufacturing engineering & industrial engineering departments are responsible for planning the process & related technical details.

Manufacturing planning includes logistics issues commonly known as.

production planning. The authorization to produce the product must be translated into "MPS" Master production schedule.

2) Master production schedule :- is a listing of the products to be made, the dates on which they are to be delivered & the quantities of each. Months are traditionally used to specify deliveries in the master schedule. Based on the schedule, the individual components & subassemblies that make up each product must be planned. Raw materials must be purchased (or) requisitioned from storage, purchased parts must be ordered from suppliers & all of these items must be planned so that they are available when needed. This entire task is called "Material requirement planning"

4) capacity planning :- In addition, the master schedule must not list more quantities of products than the factory is capable of producing each month with its given number of M/Cs & Manpower. A function called (as capacity planning is concerned with planning the manpower & Machine resources of firm.

4) Manufacturing control :- Manufacturing control is concerned with Managing & controlling the physical operations in the factory to implement the Manufacturing plans. The flow of information is as follows planning to control. Information also flows back & forth b/w Manufacturing control & the factory operations. Included in the " " functions are 1) shop floor control 2) inventory control & 3) quality control.

1) shop floor control :- Deals with problem of monitoring the progress of the product as it is being processed, assembled, moved & inspected in the factory. Shop floor control is concerned with inventory in the sense that the materials being processed in the factory are work-in-process inventory. Thus shop floor control & inventory control and quality control overlap to some extent.

2) Inventory control:— attempts to strike a proper balance b/w the risk of too little inventory (with possible stock-outs of materials) & the carrying cost of too much inventory. It deals with such issues as deciding the right quantities of materials to order & when to reorder a given item when stock is low.

3) Quality control:— is to ensure that the quality of the product & its components meet the standards specified by the product designer. To accomplish its mission, quality control depends on inspection activities performed in the factory at various times during the manufacture of the product. Also, raw materials & component parts from outside sources are sometimes inspected when they are received & final inspection & testing of the finished product is performed to ensure functional quality & appearance. Quality control also includes data collection & problem-solving approaches to address process problems related to quality.

Examples: of these approaches are statistical process control (SPC) & Six Sigma

→ Automation in production systems:— Some components of the firm's production system are likely to be automated, whereas others will be operated manually (or) clerically. The automated elements of the production system can be separated in 2 categories 1) Automation of manufacturing systems in the factory & 2) computerization of the manufacturing support systems.

In modern production systems, the 2 categories overlap to some extent, because the automated manufacturing systems operating on the factory floor are themselves usually implemented by computer systems operating on and connected to the computerized manufacturing support systems & management information system operating at the plant & enterprise levels.

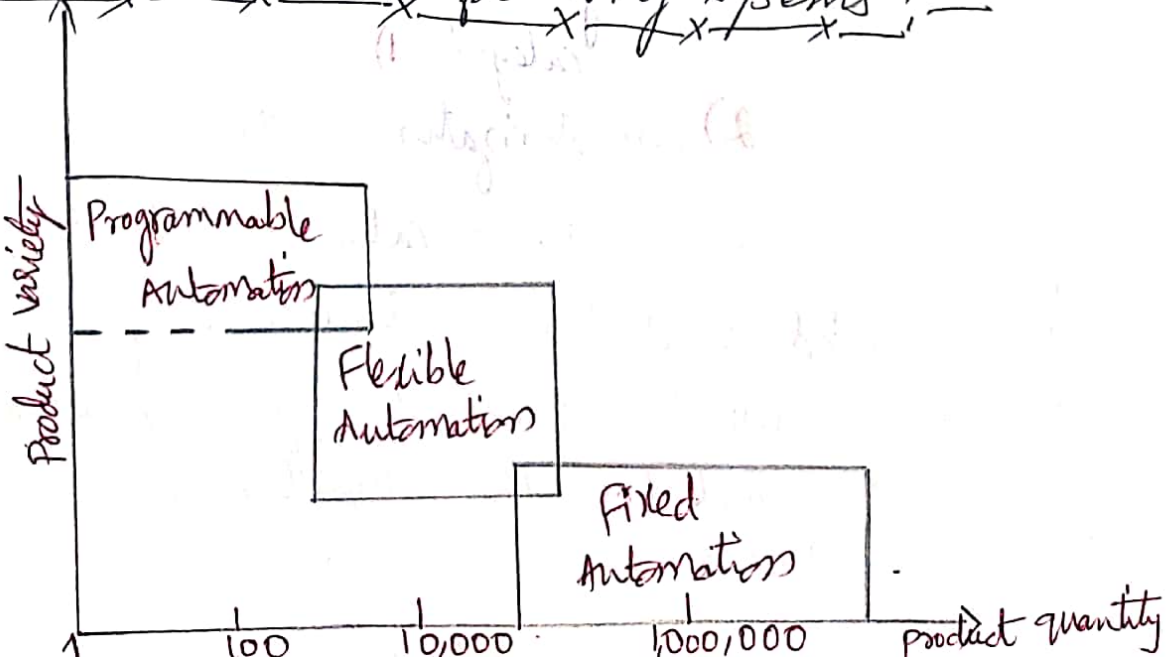
The term computer-integrated Manufacturing is used to indicate the extensive use of computers in production systems.

1) Automated Manufacturing systems :- operates in the factory on the physical product. They perform operations such as processing, assembly, inspection & material handling, in some cases accomplishing more than one of these operations in the same system. They are called automated because they perform their operations with a reduced level of human participation compared with the corresponding manual process. In some highly automated systems, there is virtually no human participation.

*Examples of Automated Manufacturing systems :-

1) Automated machine tools that process parts 2) Transfer lines that perform a series of machining operations 3) Automated assembly systems 4) Manufacturing systems that use industrial robots to performing processing (or) assembly operations 5) Automatic material handling & storage systems to integrate manufacturing operations 6) Automated inspection systems for quality control.

→ Types of Automated Manufacturing systems :-



1) fixed Automation ;- i) Fixed Automation is a system in which the sequence of processing (or) assembly) operations is fixed by the equipment configuration 2) Each operations in the sequence is simple

Typical features ;- i) Suited to high production quantities.
ii) High initial investment for custom-engineered equipment.
iii) High production rates Relatively inflexible in accomodating product variety (or) changes.
ii) Each operation in the sequence is usually simple.
iii) It is the integration and co-ordination of many such operations into one piece of equipment that makes the system complex.
iv) fixed automation is designed to do specific task. Specialized equipment - high volume at low cost, inflexible.
Examples:- Machining transfer lines & automated assembly machines.

2) programmable Automation ;- i) The production equipment is designed with capability to change the sequence of operations to accommodate different product configurations 2) The operation sequence is controlled by a program which is a set of instructions coded so that they can be read & interpreted by the system.
3) New programs can be prepared & entered into the equipment to produce new products. 4) The physical setup of the machine must be changed for each new products.

SYLLABUS

R18 B.Tech. Mechanical Engg. Syllabus JNTU HYDERABAD

ME701PC: REFRIGERATION AND AIR CONDITIONING

B.Tech. IV Year I Sem.

L	T	P	C
3	0	0	3

Pre-requisite: Thermodynamics

Course Objective: To apply the principles of Thermodynamics to analyze different types of refrigeration and air conditioning systems and to understand the functionality of the major components.

Course Outcomes: At the end of the course, the student should be able to Differentiate between different types of refrigeration systems with respect to application as well as conventional and unconventional refrigeration systems. Thermodynamically analyse refrigeration and air conditioning systems and evaluate performance parameters. Apply the principles of Psychometrics to design the air conditioning loads for the industrial applications.

UNIT – I

Introduction to Refrigeration: - Necessity and applications – Unit of refrigeration and C.O.P. – Mechanical Refrigeration – Types of Ideal cycle of refrigeration.

Air Refrigeration: Bell Coleman cycle and Brayton Cycle, Open and Dense air systems – Actual air refrigeration system – Refrigeration needs of Air crafts- Air systems – Application of Air Refrigeration, Justification – Types of systems – Problems.

UNIT – II

Vapour compression refrigeration – working principle and essential components of the plant – Simple Vapour compression refrigeration cycle – COP – Representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – Actual cycle Influence of various parameters on system performance – Use of p-h charts – Problems.

UNIT - III

System Components: Compressors – General classification – comparison – Advantages and Disadvantages. Condensers – classification – Working Principles. Evaporators – classification – Working Principles. Expansion devices – Types – Working Principles. Refrigerants – Desirable properties – common refrigerants used – Nomenclature – Ozone Depletion – Global Warming – Azeotropes and Zeotropes.

UNIT - IV

Vapor Absorption System – Calculation of max COP – description and working of NH3 – water system – Li – Br system. Principle of operation Three Fluid absorption system, salient features.

Steam Jet Refrigeration System – Working Principle and Basic Components

Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.

UNIT – V

Introduction to Air Conditioning: Psychometric Properties & Processes – Sensible and latent heat loads – Characterization – Need for Ventilation, Consideration of Infiltration – Load concepts of RSHF, ASHF, ESHF and ADP.

Concept of human comfort and effective temperature –Comfort Air conditioning – Industrial air conditioning and Requirements – Air conditioning Load Calculations.

Air Conditioning systems - Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, deodorants, fans and blowers.

Heat Pump – Heat sources – different heat pump circuits – Applications.

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Vishal Rai 26/08/22

LESSON PLAN

Staff Name : Vishal Rai Department : Mechanical Engg.

Class : B.Tech Subject : RAC Semester : I Branch : Mechanical Engg Section : Year : IV 2022

Sl. No.	Unit No.	Date	Topics to be covered	No. of periods Required	Cumulative Periods
1	I	13/9/22	Introduction to Refrigeration: - Necessity and applications	L1	2
2		13/9/22	Unit of refrigeration and C.O.P ,Mechanical Refrigeration – Types of Ideal cycle of refrigeration.	L2	
3		13/9/22	**Numericals Problems**	L3	
4		14/9/22	Air Refrigeration: Bell Coleman cycle and Brayton Cycle	L4	2
5		14/9/22	Open and Dense air systems – Actual air refrigeration system –	L5	
6		14/9/22	**Numericals Problems**	L6	
7		19/9/22	Refrigeration needs of Air crafts- Air systems – Application of Air Refrigeration,	L7	3
8		19/9/22	Justification – Types of systems	L8	
9		19/9/22	**Numericals Problems**	L9	
10		27/9/22	**Assignment-1**	L10	
11	II	21/9/22	Vapour compression refrigeration – working principle and essential components of the plant	L11	2
12		26/9/22	Simple Vapour compression refrigeration cycle – COP– Representation of cycle on T-S and p-h charts	L12	
13		26/9/22	**Numericals Problems**	L13	2
14		28/9/22	Effect of sub cooling and super heating – cycle analysis	L14	
15		27/9/22	Numericals Problems	L15	2
16		27/9/22	Actual cycle Influence of various parameters on system performance – Use of p-h charts	L16	
17		27/9/22	**Numericals Problems**	L17	
18		25/10/22	**Assignment-2**	L18	
19	III	17/10/22	System Components: Compressors – General classification	L19	2
20		17/10/22	Comparison – Advantages and Disadvantages	L20	
21		18/10/22	System Components: Compressors – General classification	L21	1
22		18/10/22	Condensers – classification – Working Principles	L22	
23		22/10/22	Evaporators – classification – Working Principles.	L23	3
24		22/10/22	Expansion devices – Types – Working Principles.	L24	
25		22/10/22	Refrigerants – Desirable properties – common refrigerants used	L25	
26		22/10/22	Nomenclature – Ozone Depletion – Global Warming – Azeotropes and Zeotropes	L26	
27		31/10/22	**Assignment-3**	L27	
28		14/11/22	Vapor Absorption System – Calculation of max COP – description and working of NH3 – water system	L28	2
29		14/11/22	**Numericals Problems**	L29	

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LESSON PLAN

Staff Name : Vishal Rai Department : Mech. Engg

Class : B.Tech Subject : ROAC Semester : I Branch : Mech Engg Section : B Year : 2022

Sl. No.	Unit No.	Date	Topics to be covered	No. of periods Required	Cumulative Periods
30	IV	15/11/2022	Vapor Absorption System – Calculation of max COP – description and working of Li – Br system.	L30	3
31		15/11/2022	Numericals Problems	L31	
32		19/11/2022	Principle of operation Three Fluid absorption system, salient features.	L32	5
33		19/11/2022	Steam Jet Refrigeration System – Working Principle and Basic Components	L33	
34		19/11/2022	Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.	L34	
35		20/11/2022	Assignment-4	L35	
36	V	3/12/2022	Introduction to Air Conditioning: Psychometric Properties & Processes	L36	4
37		3/12/2022	Sensible and latent heat loads – Characterization – Need for Ventilation, Consideration of Infiltration	L37	
38		5/12/2022	Load concepts of RSHF, ASHF, ESHF and ADP	L38	
39		5/12/2022	Numericals Problems	L39	
40		6/12/2022	Concept of human comfort and effective temperature –Comfort Air conditioning	L40	2
41		6/12/2022	Numericals Problems	L41	
42		7/12/2022	Industrial air conditioning and Requirements – Air conditioning Load Calculations.	L42	1
43		7/12/2022	Numericals Problems	L43	2
44		13/12/2022	Air Conditioning systems - Classification of equipment	L44	3
45		14/12/2022	cooling, heating humidification and dehumidification, filters, grills and registers	L45	2
46		20/12/2022	deodorants, fans and blowers.	L46	2
47		23/12/2022	Heat Pump – Heat sources – different heat pump circuits – Applications.	L47	2
48		28/12/2022	Assignment-5	L48	
			Total	48 Hours	

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Staff Sign.: Vishal Rai H.O.D. Principal :

COURSE PLAN

Staff Name : Vish Rai Department : Mech. Engg

Class : B. Tech Subject : RAC Semester : 8. Branch : Mech. Engg Section : A Year : 2022

S.No.	Unit No.	Date	Topics to be covered	No of Periods
			Course objective:-	
		*	To apply the principles of Thermodynamics to analyse different types of refrigeration and air conditioning system and to understand the functionality of the major components	
			Course outcomes:-	
		x	At the end of the course, the student should be able to Differentiate between different types of refrigeration system with respect to application as well as conventional and unconventional refrigeration system. Thermodynamically analyse refrigeration and air conditioning system and evaluate performance parameters. Apply the principles of psychometric to design the air conditioning loads for the Industrial applications.	
	Course plan		Unit module 1-5 units	
		Unit-I	① Basic refrigeration cycle and concepts, Standard rating of refrigerating machine.	
			② Representation of P-V, T-S and P-H diagrams.	
			③ Theoretical and actual cycles, performance of refrigerant cycle	
			④ Elementary Numericals on Refrigeration	
		Unit-II	* Elementary vapour compression refrigeration cycle.	
			* Representation of vapour compression refrigeration cycle on P-V, T-S and P-H diagrams.	
			* Mathematical analysis of vapour compression system.	
		Unit-III	* System Components - compressor, condenser, evaporator and Expansion devices, construction, classification and working.	
			* Difinition of refrigerant, classification of refrigerants.	
			* Properties of refrigerants and comparision with Nomenclature and Ozone depletion - Global warming, Azeotropes, Zeotropes	
		Unit-IV	* Simple vapour absorption refrigeration system. Refrigerant absorbent combinations and Absorption cycle analysis.	
		Unit-V	* Air conditioning. Psychrometric chart and its application	
			* Air conditioning systems and numericals	
			* Air conditioning System classification	TOTAL 48 hrs

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LECTURE RECORD

S.No.	Date	Time	Topics Covered	No. of Periods	Initial of HOD

S.No	Units	Date	Topic Covered	No. of Periods Required	Cumulative Periods
1	I	13/9/22	Introduction to Refrigeration: - Necessity and applications	2	2
		13/9/22	Unit of refrigeration and C.O.P ,Mechanical Refrigeration – Types of Ideal cycle of refrigeration.		
		13/9/22	**Numericals Problems**		
		14/9/22	Air Refrigeration: Bell Coleman cycle and Brayton Cycle	2	2
		14/9/22	Open and Dense air systems – Actual air refrigeration system –		
		14/9/22	**Numericals Problems**		
		19/9/22	Refrigeration needs of Air crafts- Air systems – Application of Air Refrigeration,	2	2
		19/9/22	Justification – Types of systems		
		19/9/22	**Numericals Problems**		
		27/9/22	**Assignment-1**		
2	II	21/9/22	Vapour compression refrigeration – working principle and essential components of the plant	2	2
		26/9/22	Simple Vapour compression refrigeration cycle – COP— Representation of cycle on T-S and p-h charts		
		26/9/22	**Numericals Problems**	2	2
		26/9/22	Effect of sub cooling and super heating – cycle analysis		
		27/9/22	Numericals Problems	2	2
		27/9/22	Actual cycle Influence of various parameters on system performance – Use of p-h charts		
		27/9/22	**Numericals Problems**		
		25/11/22	**Assignment-2**		
3	III	17/10/22	System Components: Compressors – General classification	2	2
		17/10/22	Comparison – Advantages and Disadvantages		
		18/10/22	System Components: Compressors – General classification	1	1
		18/10/22	Condensers – classification – Working Principles		
		22/10/22	Evaporators – classification – Working Principles.	3	3
		22/10/22	Expansion devices – Types – Working Principles.		
		22/10/22	Refrigerants – Desirable properties – common refrigerants used		
		22/10/22	Nomenclature – Ozone Depletion – Global Warming – Azeotropes and Zeotropes		
		31/10/22	**Assignment-3**		
4	IV	14/11/22	Vapor Absorption System – Calculation of max COP – description and working of NH3 – water system	2	3
		14/11/22	**Numericals Problems**		
		15/11/22	Vapor Absorption System – Calculation of max COP – description and working of Li – Br system.		
		15/11/22	**Numericals Problems**		
		29/11/22	Principle of operation Three Fluid absorption system, salient features.		

Vishal Rai

LECTURE RECORD

S.No.	Date	Time	Topics Covered	No. of Periods	Initial of HOD
		19/11/22	Steam Jet Refrigeration System – Working Principle and Basic Components	4	5
		19/11/22	Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.		
		30/11/22	**Assignment-4**		
5	V	3/12/22	Introduction to Air Conditioning: Psychometric Properties & Processes	3	4
		3/12/22	Sensible and latent heat loads – Characterization – Need for Ventilation, Consideration of Infiltration		
		5/12/22	Load concepts of RSHF, ASHF, ESHF and ADP		
		5/12/22	**Numericals Problems**	2	2
		6/12/22	Concept of human comfort and effective temperature –Comfort Air conditioning		
		6/12/22	Numericals Problems	1	1
		7/12/22	Industrial air conditioning and Requirements – Air conditioning Load Calculations.	2	2
		12/12/22	**Numericals Problems**	2	3
		13/12/22	Air Conditioning systems - Classification of equipment	1	2
		14/12/22	Cooling, heating humidification and dehumidification, filters, grills and registers	2	2
		20/12/22	deodorants, fans and blowers.	2	2
		23/12/22	Heat Pump – Heat sources – different heat pump circuits – Applications.	39	44
		28/12/2022	**Assignment-5**	39	44
			Total		

Text Books

1.Refrigeration and Air conditionong /CP Arora/MC Graw Hill

1.Refrigeration and Air conditionong /RC Arora/MC Graw Hill

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Assignment.1.

Refrigeration and Air Conditioning

Submit Date: 30/09/2023

S.No	Questions
1	Write the advantages of dense air refrigerating systems over open air refrigerating systems.
2	In a Bell- coleman cycle, air is drawn into the compressor at -50 ^{o}C and 1 bar and compressed isentropically to 5 bar and then cooled to 150 ^{o}C and then expanded in the expansion cylinder to 1 bar pressure following the law $PV^{1.2}$=C. Find the capacity of the refrigeration plant in TOR and COP of the system.
3	Explain the term ``Tonne of refrigeration
4	List the advantages and disadvantages of air refrigeration system
5	What are the applications of Refrigeration?
6	What do you understand by the COP of an air refrigeration cycle? Give its formula.
7	A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.93 kJ/kg K. The specific heat of fish below freezing point is 7.26 kJ/kg K. The fish is stored in cold storage which is maintained at -8^{0}C. The freezing point of fish is -4^{0}C. The latent heat offish is 235 kJ/kg. If the plant requires 75 kW to drive it, find.(a).The capacity of the plant, and. (b).Time taken to achieve cooling. Assume actual C.O.P. of the plant as 0.3 of the Carnot C.O.P.
8	A Bell-Coleman refrigerator operates between pressure limits of 1 bar and 8 bar. Air is drawn from the cold chamber at 9^{0}C, Compressed and then it is cooled to 29^{0}C before entering the expansion cylinder. Expansion and compression follows the law $PV^{1.35}$=constant. Calculate the theoretical COP of the system. For air take Υ =1.4, C_p=1.003 kJ/kg.K
9	With a neat sketch explain the working of Bell-Coleman cycle and derive the expression for its COP
10	An air refrigerator working on the principle of Bell-Coleman cycle. The air into the compressor is at 1 atm at -10^{0}C. It is compressed to 10 atm and cooled to 40 ^{0}C at the same pressure. It is then expanded to 1 atm and discharged to take cooling load. The air circulation is 1 kg/s. The isentropic efficiency of the compressor = 80% The isentropic efficiency of the expander = 90% Find the following: i) Refrigeration capacity of the system ii) C.O.P of the system Take γ = 1.4, C_p=1.00 kJ/kgK (solution)
11	What is the difference between Refrigeration and Air Conditioning?
12	An air refrigerator working on Bell-Coleman cycle takes in air at 1 bar and at a temperature of 100 C. The air is compressed to 5 bar abs. The same is cooled to 25^{0} C in the cooler before expanding in the expansion cylinder to cold chamber pressure of 1 bar. The compression and expansion laws followed are $PV^{1.35}$=C and $PV^{1.3}$=C respectively. Determine C.O.P of the plant and net refrigeration effect per kg of air. Take C_p = 1.009 kJ/kg K and R = 0.287 kJ/kg K for air.
13	What is the difference between a refrigerator and a heat pump? Derive an expression for the performance factor for both if they are running on reserved Carnot cycle.
14	Discuss the advantages of the dense air refrigerating system over an open air refrigeration system.
15	A dense air refrigerating system operating between pressures of 17.5 bar and 3.5 bar is to produce 10 tonnes of refrigeration. Air leaves the refrigerating coils at -7^{0}C and it leaves the air cooler at 15.5^{0}C. Neglecting losses and clearance, calculate the net work done per minute and the coefficient of performance. For air C_p=1.005 kJ/kg K and Υ=1.4.

Assignment.2.

Refrigeration and Air Conditioning

Submit Date: 05/12/2022

S.No	Questions
1	State the effects of suction pressure and discharge pressure on performance of vapour compression system?
2	Draw the vapour compression refrigeration cycle on T-s diagram when the refrigerant is dry and saturated at the end of compression and find an expression for the C.O.P in terms of (i) Temperature and entropies; (ii)Enthalpy
Question form Texbook of Refrigeration and air conditioning R.S Khurmi)	
4	**Exercise question No.** **1.**3 2. 4 3.7 4.8 5.10 6.13 7.15
5	**Example No. (i)**4.4 (ii).4.6 (iii).4.8 (iv).4.10 (v).4.17 (vi).4.23

Assignment-3

Refrigeration and Air Conditioning

Submit Date: 19/11/2023

1	Draw a neat sketch of practical vapour absorption refrigeration cycle and explain the working with indicate there on the phase of various fluid and the name of equipment.
2	Derive the equation for the estimation of max COP of vapour absorption refrigeration system and how does it affect with the generator temperature?
3	In a 100TR aqua ammonia absorption plant, saturated liquid ammonia at 30^0C leaves the condenser and enters the expansion valev. The evaporator pressure is 1.9 bar and the vapour temperature at evaporator exit is -10^0C. The mass concentrations of ammonia in the weak and strong solutions are .25 and .325 respectively. Determine the mass flow rates (in kg/min) of the strong and weak solutions.
4	Explain how a double-effect Li Br-water absorption system differs from that of single-effect system.
5	The following data refer to lithium –bromide water absorption refrigeration system. Capacity=2TR; Concentration of Libr and enthalpy values for weak solution leaving generator=.68 and 21KJ/kg respectively; Concentration of Libr and enthalpy values for strong solution leaving absorber=.58 and -55KJ/kg respectively. Temperature of water leaving condenser =400C; Enthalpy of stream leaving evaporator =2508KJ/kg; Specific heat of water=4.2 KJ/kg K. Determine the mass flow rates of strong and weak solutions in kg/min and heat transfer rates in the generator and absorber inKJ /min.
6	What is the principle of a stream jet refrigeration system and advantage and disadvantage of stream jet refrigeration system?
7	State the advantages and disadvantages of Electrolux refrigerator over conventional refrigerators.
8	Explain the working of Thermostatic Expansion valve with neat sketch. Write its advantages and disadvantages.
9	Explain with help of neat sketches, vapour absorption cycle for refrigeration. How is it different from vapour compression refrigeration system?
10	Explain the merits and demerits of thermo electric refrigeration system and derive an expression of its COP.
11	Mention the function of each fluid in a three fluid vapour absorption system.
12	Explain the working of Vortex tube refrigerator.
13	How does the Hilsch tube refrigeration system function? Explain by drawing the suitable line diagram.

Q.1.A vapour compression works on a single saturation cycle with R-12 as the refrigerant which operates between the condenser temperature of 40^0C and an evaporator temperature of -5^0C. For the modified cycle, the evaporator temperature is changed to -10^0C and other operating conditions are the same as the original cycle. Compare the power requirement for both cycles. Both system develops 15 tones of refrigeration.. The temperature of refrigeration

Q.2. In a vapour compression refrigerator, the working fluid is superheated at the end of compression and is under cooled in the condenser before throttling. Sketch a working cycle on temperature entropy diagram and show how theoretical coefficient of performance may be calculated from this diagram.

Q.3. Classify the Evaporators used in refrigeration system and explain the working of flooded type Evaporator with a neat diagram.

Q.4. List the commonly used refrigerants in practice and explain in detail desirable chemical properties of refrigerants.

Q.5. Explain the working of Thermostatic Expansion valve with neat sketch. Write its advantages and disadvantages.

Q.6. Explain the working of Vortex tube refrigerator.

Q.7. An air conditioning plant is required to supply $60m^3$ of air per minute at a DBT of 21^0C and 55%RH.The outside air is at DBT of 28^oC and 60%RH. Determine the mass of water drained and capacity of the cooling coil. Dehumidify and then to cool the air.

Q.8. With the help of a circuit diagram explain how a single air conditioning unit is used as an air-conditioner in summer and heat pump in winter.

Q.9.A vapour compression plant using R-12 operates between 350C condensing temperature and -50C evaporator temperature with saturated vapour leaving the evaporator. The plant consists of twin's cylinder, single acting compressor with 100mm stroke running at 300rpm. The volumetric efficiency is 85% and mechanical efficiency is 90%.Assuming isentropic compression, determine:1. C.O.P, 2.Power, 3. Tonnage capacity of the plant.

Q.10. State the effects of suction pressure and discharge pressure on performance of vapour compression system?

Q.11. List the different types of compressors? And explain each type usage in refrigeration systems giving proper reasons.

Q.12. With the help of a neat sketch, explain the working of an evaporative condenser

Q.13. Explain how a double-effect Li Br-water absorption system differs from that of single-effect system.

Q.14. Explain the Electrolux refrigeration system with a neat sketch. What is the purpose of hydrogen in it?

Q.15. Following data refer to an air conditioning system to be designed for an industrial process for hot and wet climate. Outer condition=30^0CDBT and 75% RH required inside condition =20^0C DBT and 60% RH. The required condition is to be achieved first by cooling and dehumidifying and then by heating. If $20m^3$ of air is absorbed by the every minute, find 1.capacity of the cooling coil in tones of the refrigeration, 2. Capacity of tar heating coil in kW; 3. Amount of water removed per hour; 4. By – pass factor of the heating coil, if its surface temperature is 35^0C.

Unit-1

S.No	Questions
1	What are the factors to be considered while the refrigeration system for an aero plane? Explain briefly.
2	Draw the schematic of a boot-strap cycle of air refrigeration system, and show the cycle on T-s diagram.
3	List the advantages and disadvantages of air refrigeration system.
4	With a neat sketch explain the working of Bell-Coleman cycle and derive the expression for its COP.
5	Give a brief description of an ideal cycle of air refrigeration.
6	Explain the working principle of Regenerative air refrigeration system with the help of configuration diagram and temperature-entropy diagram.
7	Describe with a diagram, the reduced ambient air cooling system.
8	Explain Boot strap evaporative cooling air refrigeration system. Draw its schematic and represent the processes on T-S diagram.
9	A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.93 kJ/kg K. The specific heat of fish below freezing point is 7.26 kJ/kg K. The fish is stored in cold storage which is maintained at -80C. The freezing point of fish is -40°C. The latent heat offish is 235 kJ/kg. If the plant requires 75 kW to drive it, find: i) The capacity of the plant, and ii) Time taken to achieve cooling. Assume actual C.O.P. of the plant as 0.3 of the Carnot C.O.P.
10	A Bell-Coleman refrigerator operates between pressure limits of 1 bar and 8 bar. Air is drawn from the cold chamber at 90C, Compressed and then it is cooled to 29^0C before entering the expansion cylinder. Expansion and compression follows the law $PV^{1.35}$=constant. Calculate the theoretical COP of the system. For air take Υ =1.4, Cp=1.003 kJ/kg.K
11	An air refrigerator working on the principle of Bell-Coleman cycle. The air into the compressor is at 1 atm at -10ºC. It is compressed to 10 atm and cooled to 40ºC at the same pressure. It is then expanded to 1 atm and discharged to take cooling load. The air circulation is 1 kg/s. The isentropic efficiency of the compressor = 80% The isentropic efficiency of the expander = 90% Find the following: i) Refrigeration capacity of the system ii) C.O.P of the system Take γ = 1.4, C_p = 1.00 kJ/kg ºC (solution)
12	In simple air refrigeration system the regenerative cooling reduces the temperature of air from the heat exchanger by 20^0C before it expands through the cooling turbine. The air leaves the cabin at 27^0C and the ram air temperature is 15^0C. Obtain the amount of air bleed from the refrigeration and COP. If 0.5 Kg/s of air from the main compressor is used for the air conditioning. Calculate the power requirement and tonnage of the system. Take P_{amb}= 0.8 bar, P_{ram}= 1 bar, efficiency of compressor = 0.8, efficiency of turbine= 0.8, heat exchanger effectiveness is 0.75. The cool air leaves the regenerative heat exchanger at 27^0C.
13	In a Bell- coleman cycle, air is drawn into the compressor at -5^0C and 1 bar and compressed isentropically to 5 bar and then cooled to 15^0C and then expanded in the expansion cylinder to 1 bar pressure following the law $pv^{1.2}$=C. Find the capacity of the refrigeration plant in TOR and COP of the system.

UNIT-2

S.No	Questions
1.	State the effects of suction pressure and discharge pressure on performance of vapour compression system?
2.	Draw the vapour compression refrigeration cycle on T-s diagram when the refrigerant is dry and saturated at the end of compression and find an expression for the C.O.P in terms of (i) Temperature and entropies; (ii)Enthalpy
3	An ammonia ice plant operates between condenser temperature of 35^0C and an evaporator temperature of -15^0C. It produces 5 tonnes of ice per day from water at 25^0C to ice at -5^0C. The ammonia enters as dry saturated vapor and leaves the condenser as saturated liquid. Determine: (i) The capacity of the refrigerating plant (ii) Mass flow of the refrigerant (ii) Discharge temperature of ammonia from the compressor (iv) Power of the compressor motor if the isentropic efficiency of the compressor is 85% and mechanical efficiency of the compressor is 90% (v) Relative efficiency. The latent heat of formation of ice is 335 kj / kg and specific heat of ice is 2.1 kj / kg-k.
4	In a vapour compression refrigerator, the working fluid is superheated at the end of compression and is under cooled in the condenser before throttling. Sketch a working cycle on temperature entropy diagram and show how theoretical coefficient of performance may be calculated from this diagram.
5	A compressor 10 cm x 10 cm, single acting twin cylinder, is used in a refrigeration plant which is working between 38^0C and 4^0C. The speed of the compressor is 900 rpm. Compression is isentropic and the refrigerant vapour is just dry and saturated when comes out of evaporator and refrigerant is saturated liquid when comes out of the condenser. Determine (i) The capacity of the refrigerant plant; (ii) COP of the system; (iii) Power required to run the compressor, if the volumetric efficiency of the compressor is 85%.
6	Derive an expression for finding out the mass of motive steam required per kg of water vapour produced.
7	A vapor compression refrigeration system operating between pressure limits of 7.5 bar and 1.5 bar. The vapor enters the compressor at a temperature of - 80C and the liquid leaving the condenser is at 120C. For a refrigerating effect of 2 kW, determine COP. Find the power rating of the compressor motor considering a mechanical efficiency of 85%. The enthalpies at 1.5 bar and 7.5 bar are 1692 kJ/kg and 1919 kJ/kg respectively. Liquid enthalpy is 474 kJ/kg at the end of condensation.
8	A refrigeration plant of 100 tons capacity uses R-22 as refrigerant. The condensing and evaporation pressures are 11.82 bar and 1.64 bar. The refrigerant enters the condenser dry saturated and leaves the condenser sub cooled by 100C. Actual COP is 70% of theoretical COP. Cp of vapour = 0.55 KJ/Kg K, Cp of liquid = 1.19 KJ/Kg K. Find: i) Theoretical and actual COP, ii) mass flow rate in kg/sec, iii) compressor power. The other properties of refrigerant are as follows:

Pr (bar)	Temp (^{0}C)	Specific Enthalpy (kJ/kg)		Specific Entropy (kJ/kg-k)	
		Liquid (h_f)	Sat. vapour (h_g)	Liquid (s_f)	Sat. vapour (s_g)
1.64	-30	116.1	393.1	0.8698	1.803
11.82	30	236.7	414.5	1.125	1.712

9	The temperature limits of an ammonia refrigerating system operating on simple vapor compression cycle are 25^{0}C and – 10^{0}C respectively. If the gas is dry at the end of compression, calculate the C.O.P of the system, assuming no under cooling of the liquid ammonia. Use the following table for the properties of ammonia

Temperature (^{0}C)	Liquid heat (kJ/kg)	Latent heat (kJ/kg)	Liquid entropy (kJ/kg-K)
25	298.9	1166.94	1.1242
–10	135.37	1297.58	0.5443

UNIT-3

1	What are the desirable properties of refrigerants? Explain
2	How does the increase in condenser temperature affect COP? Also explain the influence of evaporator temperature on COP. Which of the two temperatures have more influence on COP?
3	List the different types of compressors? And explain each type usage in refrigeration systems giving proper reasons.
4	With the help of a neat sketch, explain the working of an evaporative condenser.
5	Classify the Evaporators used in refrigeration system and explain the working of flooded type Evaporator with a neat diagram.
6	List the commonly used refrigerants in practice and explain in detail desirable chemical properties of refrigerants.
7	A four cylinder, single acting R-12 compressor 35 cm x 40 cm runs at 1000 r.p.m. The compressor clearance factor is 0.04 and the law of compression $pV^{1.1}$=C. the operating pressures for the vapour compression refrigeration system are: 8.47 bar (35^{0}C) and 1.004bar (-30^{0}C). The refrigerant temperatures are: entering the compressor -20^{0}C, leaving the compressor 50^{0}C; entering the condenser 45^{0}C, leaving the condenser 25^{0}C, entering the expansion valve 30^{0}C and leaving the evaporator dry saturated. Assuming that heat removed in the compressor is 26 kJ/sec. calculate: (i) The refrigerating capacity, (ii) The compressor power (iii) COP, (iv) Mass of condensing cooling water assuming the rise in temperature to be 10^{0}C. (v) Tabulate energy balance for 1 kg of refrigerant.
8	List out differences between rotary compressors and reciprocating compressors
9	Make a comparative study of flooded and non-flooded shell and tube type evaporators based on the capacity, condition of vapour leaving the evaporator, heat transfer effectiveness, construction and control.
10	Explain the working of evaporative condenser with neat diagram and explain its advantages and disadvantages over others. Give three examples of its use with proper reasoning.

11	What is refrigerant? Can water be used as a refrigerant? Explain the limitations.
12	Why centrifugal compressors are preferable as compared to reciprocating compressors? What are their relative advantages? Explain.
13	Suggest substitutes for CFC Refrigerants from the point of Ozone Depletion and Global Warming.
14	Explain the working of automatic expansion valve.
15.	List out differences between rotary compressors and reciprocating compressors
16.	Write the properties of ideal refrigerant.

UINT-4

1	What is the basic function of a compression refrigeration system? How this function is achieved in vapour absorption refrigeration system?
2	Drive an expression for the C.O.P of an ideal vapour absorption system in terms of temperature T_G at which heat is supplied to the generator, the temperature T_E at which heat is absorbed in the evaporator and the temperature T_C at which heat is discharged from the condenser and absorber.
3	Draw a neat diagram of lithium bromide water absorption system and explain its working. List the major field of application of this system.
4	Explain with help of neat sketches, vapour absorption cycle for refrigeration. How is it different from vapour compression refrigeration system?
5.	Explain the working of Vortex tube refrigerator.
6	Explain the merits and demerits of thermo electric refrigeration system and derive an expression of its COP.
7	State the advantages and disadvantages of Electrolux refrigerator over conventional refrigerators.
8	Explain the working of Thermostatic Expansion valve with neat sketch. Write its advantages and disadvantages.
9	Explain the Electrolux refrigeration system with a neat sketch. What is the purpose of hydrogen in it?
10	Draw the T-s and h-s diagrams representing steam jet refrigeration system.
11.	In an aqua- ammonia absorption refrigeration system of 10 TR capacities, the vapours leaving the generator are 100% pure NH_3 saturated at 40^oC. The evaporator, absorber, condenser and generator temperature are -20 ^oC,30 ^oC,40 ^oC, and 70 ^oC respectively. At absorber exit (strong solution),the concentration of ammonia in solution is x=.38 and enthalpy h=22kJ/kg.At generator exit(weak solution). X= .1 and h= 695kJ/kg. 1.Determine mass flow rate of ammonia in the evaporator; 2.Carry out overall mass conservation and mass conservation of ammonia in absorber to determine mass flow rate of weak and strong solutions: 3.Determine the heat rejection in absorber and condenser; 4. heat added in generator 5.COP.

UNIT-5

1	Discuss the purpose of ventilation in air-conditioning system.

2	Given for the air conditioning of a room Room conditions: 26.5^{0}C DBT and 50% RH Room sensible heat gain = 26.3 kW Room sensible heat factor = 0.82Find (i) The room latent heat gain (ii) The apparatus dew point (iii) The cubic meter per minute of air if it is supplied to the room at the apparatus dew point (iv) The cubic meter per minute of specific humidity of air if it is supplied to the room at 170 ºC.
3	What are the different types of fans used in air-conditioning systems? Discuss their applications and relative advantages and disadvantages.
4	Air from an air-conditioned room is exhausted into atmosphere through a grill. The quantity of air passes through the grill is 20 cubic meter minute. The duct area leading to the grill is 0.12 m^2 . The static pressure behind the grill is 3 mm of water. Find the effective area of grill exhausting the air into atmosphere. Take the pressure loss passing through the grill as 0.5 mm of water.
5	Define the term `` effective temperature `` and explain its importance in air conditioning system. Describe the factors which affect effective temperature.
6	Explain in brief as to how the human body reacts to changes in temperature of environment. Also explain the effect of activities on the heat load calculation for comfort application
7	With the help of a circuit diagram explain how a single air conditioning unit is used as an air-conditioner in summer and heat pump in winter.
8	Explain about Grills and Registers along with their performance effects
9	Sketch the psychrometric chart and represent the different psychrometric properties on the same.
10	What is comfort air-conditioning? Draw a rough comfort char
11	Explain any two types of humidifiers.
12	Explain the principle of various dehumidification methods.
13	For hot and dry weather conditions show the arrangement of summer air-conditioning system and represent the processes on psychometric chart.
14	Explain the factors governing optimum effective temperature.
15	What are the different Heat pump circuits? Explain any one of them with the help of neat sketch.
16	Explain the various types of axial flow fans
17	Define the ``human comfort`` and explain the factors which affect human comfort.
18	An air conditioning plant handles 4000 m^3 /min of dry air which contains 20% fresh air at 39^{0}C DBT and 20^{0}C WBT and 80% recirculated air at 24^{0}C DBT and 50% Relative Humidity. Air leaves the cooling coil at 12 ^{0}C and saturated condition. Find: (i) Total cooling load on the coil and (ii) Room Heat gain.
19	Explain the procedure to draw a grand sensible heat factor line on a psychrometric chart.
20	Give few industrial examples where heating and cooling is simultaneously required and explain why ``heat-pump`` is more suitable for such applications?

Code No: 157DK

R18

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year I Semester Examinations, February/March - 2022
REFRIGERATION AND AIR CONDITIONING
(Mechanical Engineering)

Time: 3 Hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks

1.a) Draw p-V and T-s diagrams of actual air refrigeration system and discuss the salient points.

b) In a Bell-Coleman cycle of a refrigerator system, air is taken in at 1 bar and a temperature of -8^0C. The compression ratio maintained in the compressor is 4 by following the law of compression and expansion as $PV^{1.2}$ = Constant. If the maximum temperature of the cycle is 25^0C, then find mean effective pressure, work required, net refrigerating effect and COP. [7+8]

2.a) What are the advantages, limitations and different applications of air refrigeration system? Explain.

b) A simple vapour compression cycle using F-12 is designed to take a load of 10 tons. The refrigerator and ambient temperatures are 0^0C and 30^0C respectively. A minimum temperature of -5^0C is required in evaporator and condenser for heat transfer. Find (i) mass flow rate through the system (ii) Power required in kW (iii) cylinder dimensions assuming L/D ratio as 1.2 for a single cylinder and single acting compressor running at 300 rpm with a volumetric efficiency of 0.9. [7+8]

3.a) How does the sub cooling and super heating influence the performance of vapour compression refrigeration system? Explain.

b) Explain the important components required for the operation of simple vapour compression refrigeration system. [7+8]

4.a) A single stage, single acting reciprocating compressor has a bore of 200 mm and a stroke of 300 mm. If receives vapour refrigerant at 1 bar and delivers it at 5.5 bar. If the compression and expansion follows the law $PV^{1.3}$ = constant and the clearance volume is 5% of the stroke volume, then determine (i) The power required to drive the compressor, if it runs at 500 rpm and (ii) The volumetric efficiency of the compressor.

b) Explain the principle of operation of evaporative condenser used in the refrigeration system. [7+8]

5.a) Differentiate between Azeotropes and Zeotropes and discuss their importance with respect to Ozone depletion and global warming.

b) Describe the constructional and operational features of Li-Br vapour absorption refrigeration system. [7+8]

6.a) How does the Hilsch tube refrigeration system function? Explain by drawing the suitable line diagram.

b) Derive the equation for the estimation of max COP of vapour absorption refrigeration system and how does it affect with the generator temperature? [7+8]

7.a) Air at 1 bar and 29^0C has a wet-bulb temperature of 23^0C. Determine (i) the partial pressure of water vapour (ii) the humidity ratio, (iii) the relative humidity (iv) the dew point, and (v) the enthalpy of air, and (vi) the degree of saturation per kg of dry air. Solve the problem analytically and check the results using Psychometric chart.

b) What is the need of ventilation air in the air conditioning system? Discuss the method to supply the ventilation air. [8+7]

8.a) Why does the enthalpy of an air-vapour mixture remain constant during an adiabatic saturation process?

b) The following data refer to an air conditioning system for industrial process for hot and wet summer conditions: outdoor conditions = 33^0C DBT and 78% RH, required conditions = 20^0C DBT and 73% RH, amount of out-door air supplied = 220 m^3/min, coil dew point temperature = 12^0C. If the required condition is achieved by first cooling and dehumidifying and then by heating, find: (i) The capacity of the cooling coil and its by-pass factor (ii) The capacity of the heating coil and surface temperature of the heating coil if the by-pass factor is 0.18. [7+8]

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Code No: 157DK **R18**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech IV Year I Semester Examinations, January/February - 2023
REFRIGERATION AND AIR CONDITIONING
(Mechanical Engineering)

Time: 3 Hours **Max. Marks: 75**

Note: i) Question paper consists of Part A, Part B.
ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.
iii) In Part B, Answer any one question from each unit. Each question carries 10 marks and may have a, b as sub questions.

Note: Use of Refrigeration and A/C Data book is permitted.

PART – A

(25 Marks)

1.a)	Explain the differences of Bell Coleman and Brayton cycle operating conditions.	[2]
b)	Explain the refrigeration unit of measurement.	[3]
c)	Explain the role of Throttle valve in VCR system.	[2]
d)	What are the parameters affecting the COP of VAR system?	[3]
e)	Explain the reasons for the Ozone depletion.	[2]
f)	Enumerate the details and applications of Azeotropes.	[3]
g)	Explain the basic principle of Vortex tube.	[2]
h)	Describe the working principle of three fluid VARS.	[3]
i)	Explain the significance of comfort zone in comfort chart.	[2]
j)	What is the basic importance and applications of deodorants?	[3]

PART B

(50 Marks)

2. An air craft moving with speed of 1000 km/h uses simple gas refrigeration cycle for air conditioning. The ambient pressure and temperature are 0.35 bar and -10^0C respectively. The pressure ratio of compressor is 4.5. The heat exchanger effectiveness is 0.95. The isentropic efficiencies of compressor and expander are 0.8 each. The cabin pressure and temperature are 1.06 bar and 25^0C. Determine temperature and pressures at all points of the cycle. Also find the volume flow rate through compressor inlet and expander outlet for 100 TR. Take C_P=1.005 kJ/kg K; R=0.287 kJ/kg K and C_P/C_V=1.4 for air. [10]

OR

3. Explain Boot strap evaporative cooling of air refrigeration system. Draw its schematic diagram and represent the processes on P-h and T-S diagrams. Write down the equations for calculating the power and COP of the system. [10]

4. In an ammonia vapor compression refrigerator, the temperature is refrigerator is -10^0C and temperature of NH_3 coming out of compressor is 30^0C. The vapor is condensed in the condenser at 30^0C. Find the theoretical C.O.P. of the cycle when the vapor at the end of compression is 0.9 dry. Latent heat of NH_3 at 30^0C = 1442 kJ/kg. Specific heat of liquid NH_3 = 4.7 kJ/kg. [10]

OR

5. What are the differences between ideal and actual VCRS. Derive the expression for COP of actual VCRS. [10]

6.a) How do you nomenclature to a refrigerant?

b) Write a note on global warming due to refrigerants . [5+5]

OR

7. A refrigerating plant works between -10^0C evaporator temperature and 40^0C condenser temperature when F-12 is used as refrigerant. A compressor used has 2 cylinders and the diameter and stroke of the cylinder are 56.5 mm and 50 mm respectively. If the clearance is 4% of the stroke and compressor runs at 1450 R.P.M., find the following:
a) Refrigerating capacity of the plant b) Power required to run the compressor c) COP of the system. Take Υ=1.13 for F-12. [10]

8. In an absorption type refrigerator, the heat is supplied to NH_3 generator by condensing steam at 2 bar and 90% dry. The temperature to be maintained in the refrigerator is - 5^0C. The temperature of the atmosphere is 30^0C. Find the maximum C.O.P. possible of the refrigerator. If the refrigeration load is 20 tons and actual C.O.P. is 70% of maximum C.O.P., find the mass of steam required per hour. [10]

OR

9.a) Explain the working details and the advantages of Thermo Electric Refrigerator .

b) Describe briefly the working principle of production of hot and cold air from a vortex tube. [5+5]

10. Atmospheric air at 35^0C and 60% R.H. is conditioned to 22^0C DBT and 55% R.H. This is done first by cooling and dehumidifying and then heating. If the quantity of air flow is 60 cu. m. per minute find the following. a) Mass of water drained. b) Capacity of cooling coil. c) Capacity of heating coil. Take pt= 1.033 bar. [10]

OR

11.a) With the neat diagram, explain the working of adiabatic humidifier.

b) Write a short notes on Fans and blowers. [5+5]

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Code No: RT32037A | R13 | SET - 1

III B. Tech II Semester Supplementary Examinations, April/May - 2019

REFRIGERATION AND AIR CONDITIONING

(Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART - A

1 a) What are the applications of Refrigeration? [3M]
b) Represent ideal vapour compression refrigeration system on T-S and P-h diagrams. [4M]
c) 'A completely odourless refrigerant is not desirable', discuss the statement. [3M]
d) Identify various psychometric process applied to Air conditioning systems. [4M]
e) Explain in brief, an adiabatic saturation process. [4M]
f) What is the function of a fan in an air conditioning system? [4M]

PART – B

2 a) In simple air refrigeration system the regenerative cooling reduces the temperature of air from the heat exchanger by 20^0C before it expands through the cooling turbine. The air leaves the cabin at 27^0C and the ram air temperature is 15^0C. Obtain the amount of air bleed from the refrigeration and COP. If 0.5 Kg/s of air from the main compressor is used for the air conditioning. Calculate the power requirement and tonnage of the system. Take P_{amb}= 0.8 bar, P_{ram}= 1 bar, efficiency of compressor = 0.8, efficiency of turbine= 0.8, heat exchanger effectiveness is 0.75. The cool air leaves the regenerative heat exchanger at 27^0C. [8M]

b) Explain the working principle of Regenerative air refrigeration system with the help of configuration diagram and temperature-entropy diagram. [8M]

3 a) The temperature limits of an ammonia refrigerating system operating on simple vapor compression cycle are 25^0C and – 10^0C respectively. If the gas is dry at the end of compression, calculate the C.O.P of the system, assuming no under cooling of the liquid ammonia. Use the following table for the properties of ammonia. [8M]

Temperature (^{0}C)	Liquid heat (kJ/kg)	Latent heat (kJ/kg)	Liquid entropy (kJ/kg-K)
25	298.9	1166.94	1.1242
–10	135.37	1297.58	0.5443

b) State merits and demerits of 'Vapor compression system' over' Air-refrigeration system' [8M]

4 a) A four cylinder, single acting R-12 compressor 35 cm x 40 cm runs at 1000 r.p.m. The compressor clearance factor is 0.04 and the law of compression $pV^{1.1}=C$. the operating pressures for the vapour compression refrigeration system are: 8.47 bar (35^0C) and 1.004bar (-30^0C). The refrigerant temperatures are: entering the compressor -20^0C, leaving the compressor 50^0C; entering the condenser 45^0C, leaving the condenser 25^0C, entering the expansion valve 30^0C and leaving the evaporator dry saturated. Assuming that heat removed in the compressor is 26 kJ/sec. calculate: [8M]

(i) The refrigerating capacity,
(ii) The compressor power
(iii) COP,
(iv) Mass of condensing cooling water assuming the rise in temperature to be 10^0C.
(v) Tabulate energy balance for 1 kg of refrigerant.

b) Explain the operation of a capillary tube in a refrigeration system with a neat sketch. [8M]

5 a) List out differences between rotary compressors and reciprocating compressors. [8M]

b) Explain the merits and demerits of thermo electric refrigeration system and derive an expression of its COP. [8M]

6 a) For hot and dry weather conditions show the arrangement of summer air-conditioning system and represent the processes on psychometric chart. [8M]

b) Explain the factors governing optimum effective temperature. [8M]

7 a) What are the different Heat pump circuits? Explain any one of them with the help of neat sketch. [8M]

b) Explain the various types of axial flow fans. [8M]

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Code No: RT32037A | R13 | SET - 1

III B. Tech II Semester Supplementary Examinations, November - 2019

REFRIGERATION AND AIR CONDITIONING

(Mechanical Engineering)

Time: 3 hours | Maximum Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answering the question in **Part-A** is compulsory
3. Answer any **THREE** Questions from **Part-B**

*****

PART –A (22 Marks)

1 a) Explain the term ``Tonne of refrigeration``. [3M]
b) Explain the effects of super heating on COP of vapor compressor refrigeration system. [4M]
c) Classify refrigerants. [3M]
d) Explain the Seebeck and Peltier effects. [4M]
e) Explain in brief, an adiabatic saturation process. Represent the same on a Psychrometric chart. [4M]
f) Differentiate between air cooler and air conditioner. [4M]

PART –B (48 Marks)

2 a) List the advantages and disadvantages of air refrigeration system. [6M]
b) Explain Boot strap evaporative cooling air refrigeration system. Draw its schematic and represent the processes on T-S diagram. [10M]

3 a) How does an actual vapour compression cycle differ from that of a theoretical cycle? [6M]
b) A refrigeration plant of 100 tons capacity uses R-22 as refrigerant. The condensing and evaporation pressures are 11.82 bar and 1.64 bar. The refrigerant enters the condenser dry saturated and leaves the condenser sub cooled by 10^0C. Actual COP is 70% of theoretical COP. C_p of vapour = 0.55 KJ/Kg K, Cp of liquid = 1.19 KJ/Kg K. Find: i) Theoretical and actual COP, ii) mass flow rate in kg/sec, iii) compressor power. The other properties of refrigerant are as follows: [10M]

Pr (bar)	Temp (^{0}C)	Specific Enthalpy (kJ/kg)		Specific Entropy (kJ/kg-k)	
		Liquid (h_f)	Sat. vapour (h_g)	Liquid (s_f)	Sat. vapour (s_g)
1.64	-30	116.1	393.1	0.8698	1.803
11.82	30	236.7	414.5	1.125	1.712

4 a) Suggest substitutes for CFC Refrigerants from the point of Ozone Depletion and Global Warming. [8M]
b) Explain the working of automatic expansion valve. [8M]

5 a) Explain with a neat sketch, the working of a vortex tube? [8M]
b) Explain with neat sketch working of Electrolux Refrigerator also explain significance of Hydrogen used in system. [8M]

6 a) Explain the difference between comfort air-conditioning and industrial air-conditioning. [6M]
b) Explain in detail the factors that govern optimum effective temperature. [5M]
c) Explain the following: i) Bypass factor, ii) Effective sensible heat factor. Discuss their importance in designing air conditioning system. [5M]

7 a) With a neat sketch explain the working of winter air conditioning system. [8M]
b) With neat sketch explain construction and working of any one type of humidifier. [8M]

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Unit -1

Definination of Refrigeration :-

"The Science of providing and maintaining the temperature of a substance or space below that of its surrounding temperature"

→ Surrounding temperature means temperature of the atmosphere

→ A refrigeration system works on second law of thermodynamics

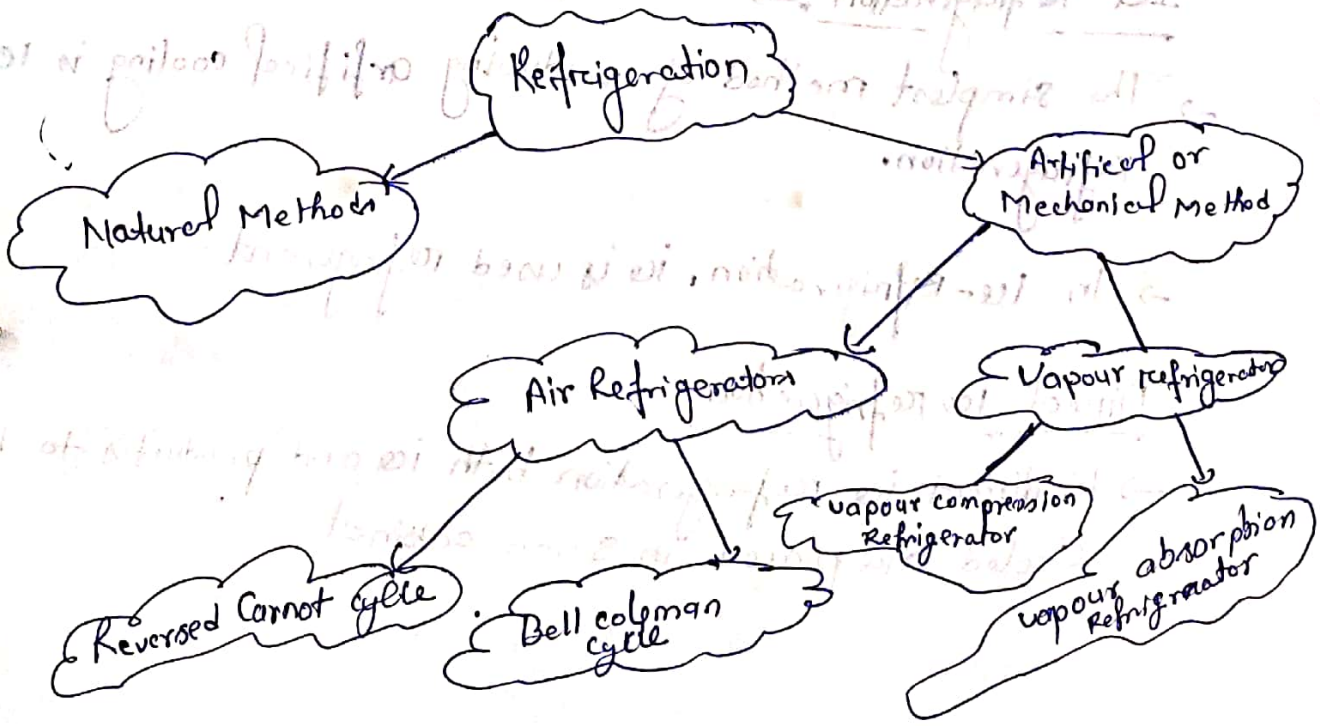
or

" Refrigration is defined as the production of temperatures lower than those of the surroundings and maintaining the lower temperature within the boundary of given space"

or

" Refrigration is the process of removing heat from a space or substance to reduce and maintain temperature lower than its surroundings"

Classification of Refrigerators:-



Natural Methods :-

The Refrigeration effect produced by bringing the substance to be cooled in direct or in direct contact with cooling medium such as chilled water or ice.

Mechanical Methods :-

The Refrigeration effect is produced by supplying the energy in the form of work or heat to operate the system.

Methods of Refrigeration

1. Ice Refrigeration
2. Dry Ice Refrigeration
3. Evaporative Refrigeration
4. Liquid Nitrogen Refrigeration
5. Refrigeration by throttling of gas
6. Steam jet-water Refrigeration
7. Air Refrigeration
8. Vapour Compression Refrigeration
9. Vapour absorption Refrigeration.

Ice Refrigeration :->

-> The simplest method of producing artificial cooling is ice Refrigeration.

-> In Ice-Refrigeration, ice is used refrigerant.

Direct ice refrigeration

-> In direct ice refrigeration both ice and products to be Cooled are placed in same cabinet.

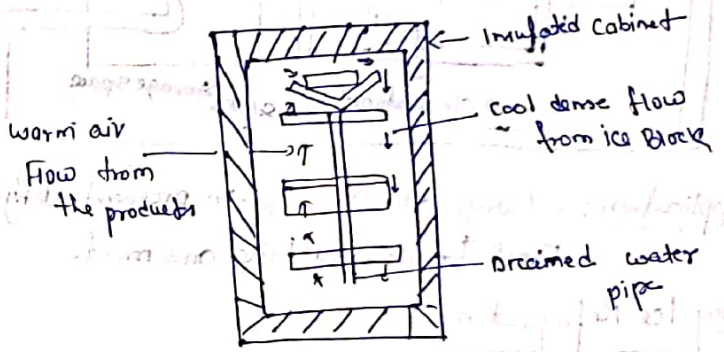
-> Ice is kept in the trays at the top and products to be cooled are placed in the bottom of an insulated cabinet.

-> Ice cools the surrounding air in the cabinet.

-> Due to high density cold air comes in direct contact and absorbs heat from the products placed in the cabinet.

-> The products are cooled and the warm air goes up and gets cooled by melting the ice and temperature maintained is about 10°C.

Applications :- Cooling of drinks in the hotels and shop.



Indirect Ice Refrigeration :-

- In in-direct ice refrigeration, ice and product to be cooled are Placed in separate space.

-> A mixture of ice and salt is kept in a storage tank Surrounding by network of tubes containing brine solution.

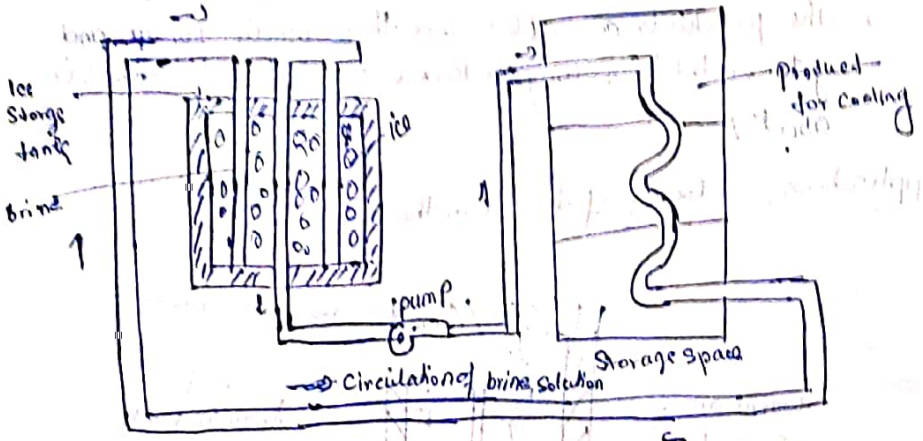
-> Mixing of salt reduce the melting point of ice to -7.9°C.

-> Ice mixture cools the brine solution.

→ This cold brine solution is circulated through the storage space where the products are kept for cooling.

→ Brine absorbs heat from the products and the products cooled.

→ The warm brine then returned to the ice storage tank and cool by rejecting its heat to the ice mixture.



Application :- Large cold storage to prevent dehydration of Fresh fruits, vegetable and meet.

Dry Ice Refrigeration

→ Solid Carbon dioxide (Solid CO_2) is known as Dry ice.

→ it changes its state from solid to vapour directly without p through the liquid state.

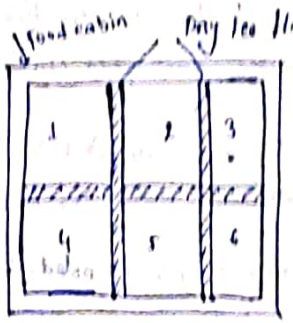
→ This Prouss is called sublimation.

→ Solid carbon dioxide evaporates at a temperature of -7 at atmospheric pressure.

→ Dry ice is cut into various shapes and kept in the side of frozen food cartoons as shown in fig.

→ it absorbs latent heat from the products in the cartoons and evaporates.

→ Thus low temperature is created in the cartoons and the products are maintained in the frozen state.



Applications:- Preservation of perishable food items in air-craft transportations.

Steam Jet - water Refrigeration :-

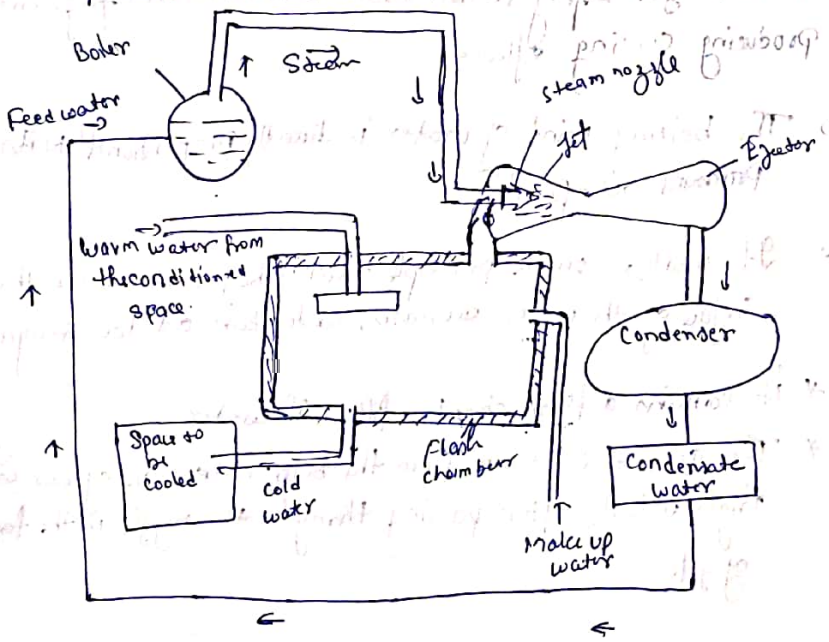
→ Steam jet Refrigeration uses chilled water as refrigerant for Producing cooling effect.

→ The boiling point of water is directly proportional to its Pressure acting on it.

→ It works on the principle that if the pressure over the surface of the water decreases, water boils at low temperature.

* it contains a flash chamber filled with water.
* The generated steam from the boiler enters an ejector with high velocity after passing through the nozzle in the form of jet.

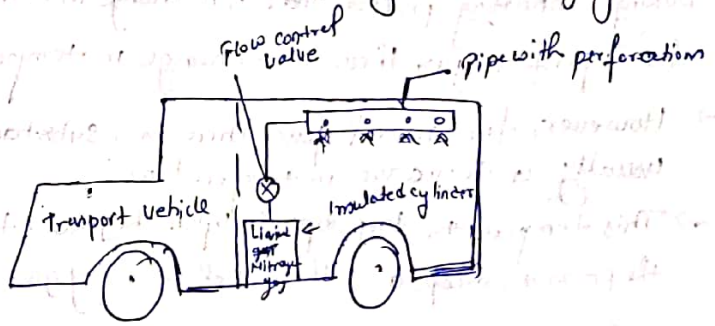
* The steam jet sweeps the vapours and gases present over the surface of the water in the flash chamber.
* This creates low pressure above the water surface and water starts evaporating at low temperature in the flash chamber.
* During evaporation, water absorbs heat from the remaining wat in the flash chamber and gets chilled.
* This chilled water is circulated to the space to be refrigerat space is sprayed back into the flash chamber.
* cold water heat and the space is cooled. The warm water from the refr
* Thus the cycle repeats. The steam ejector draws the evaporati and discharged to the condenser.
* The condensate is reused as feed water to the boiler.
* Make up water is supplied to compensate the loss of water du evaporation into the flash chamber.



Liquid gas (Nitrogen) Refrigeration :-

* Liquid gas such as nitrogen, which is non-toxic is used for producing refrigeration effect.
* It works on the priciple that substance which are gaseous state under normal conditions, will be in the liquid state every low temperature.
* It is filled in a well insulated cylinder which is conneeted to a pipe with intermittent perforations.
* Required quantity of liquid nitrogen is passed through the pipe and sprayed through the perforations into the space to be cooled.
* The quantity of Nitrogen is regulated by means of a valve.
* The temperature produced in the space may be -20°C. Liquid gas vaporise after absorbing heat, and the gas is released to atmosphere.

Application:- Cooling fluids, vegetables, meat, fish and other food.
→ used in transporting vehicles carrying food stuffs.



Air Expansion Refrigeration :-

* In this Method air is compressed to 5 bar and cooled down at constant pressure.
* It is then expanded adiabatically to a pressure of 1 bar.
* This gives the ~~mixture~~ maximum temperature reduction in a given pressure ranges, because work is done by expense of internal energy depends on the temperature.
* The cold air thus obtained is circulated through the cold cha to remove heat from the product stored in it.

Evaporating :-

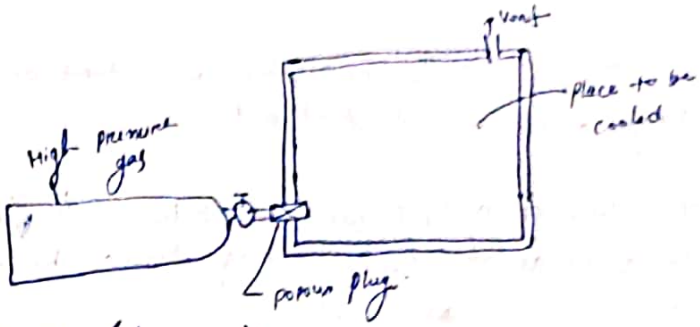
Evaporative Refrigeration :-

→ This is the oldest method of providing cooling effect.
→ In this method water evaporates by absorbing latent heat fr surrounding air.
→ Thus the air is cooled, and circulated to the cold chamber

Application :- Used for making artificial snow.

Gas Throttling Refrigeration :-

→ During throttling process there is no change in enthalpy, and for a perfect gas, there is no change in temperature.
→ However, for actual gases there is a substantial cha usually a decrease in temperature.
→ This temperature drop depends upon the joule – thomas coe the pressure drop, and the initial state of gas.
→ High pressure gas is throttled through porous plug the space to be cooled and escapes outside after abs heat from the space



Terminology of Refrigeration :-

1. Sensible Heat :-

→ The amount of heat removed or extracted from a substance without changing its state is called sensible heat.

The Temperature of the substance decreases on removing the sensible heat.

The amount of heat added to substance without changing its state is also called a sensible heat.

→ The temperature of the substance increases on adding the sensible heat.

$$Q_s = mc\Delta t = mc(t_1 - t_2)\,kJ$$

m = mass of the substance in kg
c = specific heat of the substance in kJ/kg-K
Δt = change in temperature in k or °c
t_1 = Initial tem. in k or °c
t_2 = final tem. in k or °c

dent Heat :- The amount of heat removed or extracted from a substance during plase change (change of state) is called latent heat.

→ The temperature of the substance is constant during phase change on removed of latent heat.

→ The amount of heat added to a substance during change is also called as latent heat. The temperature of the substance rises on adding the latent heat.

$$Q_L = mL$$

m = mass of the substance in kg

L = Latent heat of the substance in kJ/kg

Total heat:- $Q = Q_s + Q_L$

Refrigeration:- The process of producing cooling effect in the given space is termed as refrigeration.

Refrigeration System:-
The Equipment used to maintain lower temperature in the given space is known as refrigeration system.

Refrigerating machine :-
→ The machine used to cool a given space is known as refrigerating machine

Refrigerant :- in a refrigeration system, the work fluid used to extract heat from the given space is known as refrigerant.

Refrigeration effect:
The amount of cooling effect produced by a refrigerating machine is known as refrigeration effect.

Refrigeration effect = Cooling effect produced
= Heat extracted or heat absorbed or heat removed from the space

Work supplied:-
The amount of energy supplied to the refrigerating machine is termed as work supplied.

One ton of refrigeration :-
The amount of cooling effect produced by uniform melting of one ton of ice from and at 0°C in 24 hours.

or

The amount of heat removed to produce one ton of ice at 0°C from water at 0°C in 24 hours

or

Heat removal from the ice at the rate of 210 kJ/min

Explanation :-
One ton of ice = 1000 kg
Latent heat of fusion of ice = 336 kJ/kg
Time = 24 × 60 = 1440 minutes

Heat required for melting one ton of ice from and at 0°C in 24 hours.

$$Q = mL = 1000 \times 336 = 336000 \text{ kJ/day}$$

$$TR = \frac{336000}{24 \times 60} = 233 \text{ kJ/min}$$

One ton of refrigeration is taken as 210 kJ/min

$$1TR = 210 \text{ kJ/min}$$

$$\therefore 1TR = \frac{210}{60} = 3.5 \text{ kJ/sec} = 3.5 \text{ kW}$$