SSC-JE

Staff Selection Commission

Junior Engineer

Mechanical Engineering

Topicwise Objective Solved Questions

Previous Years Solved Papers : 2007-2023

*Also useful for **RRB-JE Mains** as well as various* **public sector examinations** and other competitive examinations

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Preface

B. Singh (Ex. IES)

Staff Selection Commission-Junior Engineer has always been preferred by Engineers due to job stability. SSC-Junior Engineer examination is conducted every year. MADE EASY team has deeply analyzed the previous exam papers and observed that a good percentage of questions are repetitive in nature, therefore it is advisable to solve previous years papers before a candidate takes the exam.

The SSC JE exam is conducted in two stages as shown in table given below.

Papers	Subject	Maximum Marks	Duration
Stage 1: Paper-I : Objective type	(i) General Intelligence & Reasoning (ii) General Awareness (iii) General Engineering : Mechanical	50 Marks 50 Marks 100 Marks	2 hours
Stage 2: Paper-II : Objective Type	General Engineering : Mechanical	300 Marks	2 hours
Note: In Paper-I, every question carry one mark and there is negative marking of ¼ marks for every wrong answer. Candidates shortlisted in Stage 1 are called for Stage 2. On the basis of combined score in Stage 1 and Stage 2, final merit list gets prepared.			

MADE EASY has taken due care to provide complete solution with accuracy. Apart from Staff Selection Commission-Junior Engineer, this book is also useful for Public Sector Examinations and other competitive examinations for engineering graduates.

I have true desire to serve student community by providing good source of study and quality guidance. Any suggestion from the readers for improvement of this book is most welcome.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

Syllabus of Engineering Subjects

(For both Objective and Conventional Type Papers)

Mechanical Engineering

Theory of Machines and Machine Design: Concept of simple machine, Four bar linkage and link motion, Flywheels and fluctuation of energy, Power transmission by belts – V-belts and Flat belts, Clutches – Plate and Conical clutch, Gears – Type of gears, gear profile and gear ratio calculation, Governors – Principles and classification, Riveted joint, Cams, Bearings, Friction in collars and pivots.

Engineering Mechanics and Strength of Materials: Equilibrium of Forces, Law of motion, Friction, Concepts of stress and strain, Elastic limit and elastic constants, Bending moments and shear force diagram, Stress in composite bars, Torsion of circular shafts, Buckling of columns – Euler's and Rankin's theories, Thin walled pressure vessels

Thermal Engineering: Properties of Pure Substances : p-v & P-T diagrams of pure substance like H2O, Introduction of steam table with respect to steam generation process; definition of saturation, wet & superheated status. Definition of dryness fraction of steam, degree of superheat of steam. h-s chart of steam (Mollier's Chart). 1st Law of Thermodynamics : Definition of stored energy & internal energy, 1st Law of Thermodynamics for cyclic process, Non Flow Energy Equation, Flow Energy & Definition of Enthalpy, Conditions for Steady State Steady Flow; Steady State Steady Flow Energy Equation.
2nd Law of Thermodynamics : Definition of Sink, Source Reservoir of Heat, Heat Engine, Heat Pump & Refrigerator; Thermal Efficiency of Heat Engines & co-efficient of performance of Refrigerators, Kelvin – Planck & Clausius Statements of 2nd Law of Thermodynamics, Absolute or Thermodynamic Scale of temperature, Clausius Integral, Entropy, Entropy change calculation for ideal gas processes. Carnot Cycle & Carnot Efficiency, PMM-2; definition & its impossibility.

Air standard Cycles for IC engines : Otto cycle; plot on P-V, T-S Planes; Thermal Efficiency, Diesel Cycle; Plot on P-V, T-S planes; Thermal efficiency. IC Engine Performance, IC Engine Combustion, IC Engine Cooling & Lubrication.

Rankine cycle of steam : Simple Rankine cycle plot on P-V, T-S, h-s planes, Rankine cycle efficiency with & without pump work. Boilers; Classification; Specification; Fittings & Accessories : Fire Tube & Water Tube Boilers. Air Compressors & their cycles; Refrigeration cycles; Principle of a Refrigeration Plant; Nozzles & Steam Turbines

Fluid Mechanics & Machinery: Properties & Classification of Fluids : ideal & real fluids, Newton's law of viscosity, Newtonian and Non-Newtonian fluids, compressible and incompressible fluids. Fluid Statics : Pressure at a point. Measurement of Fluid Pressure : Manometers, U-tube, Inclined tube. Fluid Kinematics : Stream line, laminar & turbulent flow, external & internal flow, continuity equation. Dynamics of ideal fluids : Bernoulli's equation, Total head; Velocity head; Pressure head; Application of Bernoulli's equitation. Measurement of Flow rate Basic Principles : Venturimeter, Pilot tube, Orifice meter. Hydraulic Turbines: Classifications, Principles. Centrifugal Pumps : Classifications, Principles, Performance.

Production Engineering: Classification of Steels : mild steal & alloy steel, Heat treatment of steel, Welding – Arc Welding, Gas Welding, Resistance Welding, Special Welding Techniques i.e. TIG, MIG, etc. (Brazing & Soldering), Welding Defects & Testing; NDT, Foundry & Casting – methods, defects, different casting processes, Forging, Extrusion, etc, Metal cutting principles, cutting tools, Basic Principles of machining with (i) Lathe (ii) Milling (iii) Drilling (iv) Shaping (v) Grinding, Machines, tools & manufacturing processes.

■■■■

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SSC-JE

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CHAPTER 1

Paper - I : Objective

Production Engineering

1. Metal Casting

1.1 The purpose of chaplets is
(a) just like chills to ensure directional solidification
(b) to provide efficient venting
(c) to support the cores
(d) to join lower and upper parts of the moulding box [SSC-JE : 2007]

1.2 The chief advantage of die casting is
(a) possibility of incorporating thick sections in small castings
(b) casting of inserts is possible
(c) wide tolerances are possible
(d) high production rates are possible
[SSC-JE : 2007]

1.3 Uniform sand hardness is obtained throughout the mould by which of the following moulding machines?
(a) Diaphragm moulding
(b) Stripper plate
(c) Sand slinger
(d) Squeezing [SSC-JE : 2008]

1.4 The main advantage of shell moulding is that:
(a) a metallic pattern is used
(b) the moulds are stronger
(c) thin sections can be easily obtained
(d) high production rate is possible
[SSC-JE : 2008]

1.5 In sand moulding, the bottommost part of the flask is called:
(a) cope (b) cheek
(c) drag (d) flask bottom
[SSC-JE : 2008]

1.6 In order to ram the sand softer on the pattern face and harder at the back of the mould, which of the following types of moulding machines is used?
(a) Jolt (b) Sand slinger
(c) Squeezing (d) Stripper plate
[SSC-JE : 2008]

1.7 The taper provided on pattern for its easy and clean withdrawal from the mould is called :
(a) taper allowance
(b) draft allowance
(c) distortion allowance
(d) pattern allowance [SSC-JE : 2009]

1.8 Which of the following is not a casting process?
(a) Carthias process
(b) Extrusion
(c) Semi-centrifuge method
(d) Slush process [SSC-JE : 2009]

1.9 Surfaces to be machined are marked on the pattern by the following colour:
(a) Black (b) Yellow
(c) Red (d) Blue
[SSC-JE : 2010]

1.10 In order to facilitate the withdrawal of pattern:
(a) Pattern is made smooth
(b) Water is applied on pattern surface
(c) Allowances are made on pattern
(d) Draft is provided on pattern
[SSC-JE : 2010]

1.11 Which of the following is not a casting defect?
(a) Hot tear (b) Blow hole
(c) Scab (d) Decarburisation
[SSC-JE : 2010]

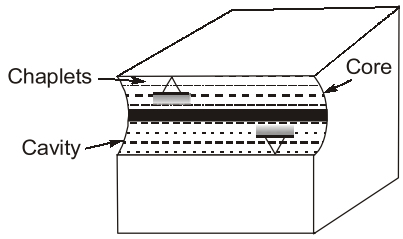
1.12 Cope in foundry practice refers to:
(a) Bottom half of moulding box
(b) Top half of moulding box
(c) Middle portion of the moulding box
(d) Coating on the mould face
[SSC-JE : 2010]

Explanations **Production Engineering**

1. Metal Casting

1.1 **(c)**

These are the metallic objects used to support the core inside the cavity, these are made up of same material as of casting.



1.2 **(d)**

1. Excellent dimensional accuracy.
2. Smooth cast surfaces
3. Thinner walls can be cast compared to sand and permanent mold casting.
4. Inserts can be cast in such as threaded inserts, heating elements, and high strength bearing surfaces.
5. Reduces or eliminates secondary machining operations.
6. Rapid production rates.

The chief advantage is high production rates are possible.

1.3 **(a)**

It consists of a bed resembling the shape of a trolley. The match plate and the moulding flask are mounted on a trolley that can be shifted along the machine bedways. An air actuated piston connected to the trolley actuates the movements of the trolley. An air operated diaphragm is mounted on the machine at a suitable position.

The pattern is placed in a suitable flask at the trolley and filled with sand. The trolley is then shifted under a pressure head. This head carries a rubber diaphragm at the bottom. Air pressure from the cylinder moves the diaphragm downwards helps in the uniform packing of sand. The trolley is then shifted to its original position and the excess sand is removed. It is a very quick process and produces a fair degree of precision.

1.4 **(c)**

The advantage of shell moulding are:

1. Better surface finish
2. Better dimensional tolerances
3. Reduced machining
4. Less foundry space required
5. Low labour costs
6. Can be easily automated for mass production
7. High productivity
8. Complex shapes can be made as there is no need to withdraw the pattern
9. Very fine details and thin sections can be obtained.

High production rate can also be associated with other special casting process, thus, answer is (c).

1.5 **(c)**

In sand moulding, the bottom most part of the flask is called drag, the uppermost one is called cope and any intermediate between cope and drag is called cheek.

1.6 **(c)**

In order to ram the sand softer on the pattern face and harder at the back of the mould, squeeze ramming is used. In squeeze ramming, a plate slightly smaller than the inside dimensions of the moulding flask is fitted into the flask already fitted with the moulding sand. A uniform pressure is applied on the plate, which compacts the sand uniformly. The sand next to the plate rams hardest while the sand below (face of pattern) is progressively less hard.

1.7 **(b)**

The taper provided on pattern for its easy and clean withdrawal from the mould is called draft allowance.

Draft allowance is also called as taper allowance. The amount of draft allowance will depend upon vertical height of pattern.

Note: For disposable/expandable pattern, draft and shaking allowances are not required.

1.8 (b)

Extrusion is not a casting process.

Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed through a die of desired cross-section. It is used for manufacturing long and straight parts.

1.9 (c)

Pattern colour coding practice is followed in the foundry in order to give the necessary information to the mould maker.

1. Black : Surface is not to be finished but left as cast.
2. Red : Surface is to be machined.
3. Yellow : Core prints
4. Yellow strips on Red : Seats for loose pieces.

1.10 (d)

In order to facilitate the withdrawal of pattern, draft is provided on pattern. At the time of withdrawing the pattern from the sand mould, the vertical faces of the pattern are in continuous contact with the mould wall, which may damage the mould cavity. To avoid this, the vertical faces are always tapered from the parting plane. This allowance ranges from 1/2° to 2°. Draft is always provided as extra metal over and above the final dimensions of the pattern.

1.11 (d)

Decarburization is a surface degradation phenomenon in the forging and heat treating of steels.

Decarburization may be described as a metallurgical process in which the surface of steel is depleted of carbon by heating above the lower critical temperature or by chemical action.

1.12 (b)

Cope in foundry practice refers to top half of moulding box. The bottom half is called drag and any intermediate flask used in case of three piece moulding is called cheek.

1.13 (a)

Shrinkage allowance is made by adding to external and internal dimensions.

1.14 (d)

Hot tears is the rupturing of casting during cooling as the metal has restraint to contraction, thus developing residual stress which finally leads rupture of casting.

1.15 (b)

- Arbor is not a foundry tool. It is a shaft on which machining tool is mounted. eg milling machine.
- Shovel tool is used for mixing and tempering moulding sand and for moving the sand pile to flask.
- Trowel tool is used to shape and smooth the surfaces of the mould and for doing small repairs. They are made of steel and are relatively long and narrow.
- Riddle tool is a screen or sieve used to remove small pieces of metal and foreign particles from the moulding sand.

1.16 (b)

The vertical passage for bringing molten metal to mould cavity is called sprue.

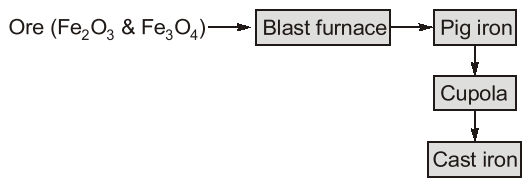
Ideal shape of the sprue is parabolic shape but due to difficulty in manufacturing of parabolic shape, we used tapered shape.

1.17 (a)

The process of pouring molten metal in the cavity of a metallic mould by gravity is called permanent mould casting. Generally two halves of a mould are made from materials such as cast iron, steel, bronze, graphite or refractory metal alloys.

1.18 (d)

Cupola is best suited for melting ferrous metals. It is used to produce cast iron (a ferrous metal). Pig iron is supplied to furnace. Pig iron is produced in blast furnace.



CHAPTER 2

Paper - I : Objective

Thermodynamics

1. Basic Concepts & Zeroth Law of Thermodynamics

1.1 According to which law, all perfect gases change in volume by 1/273rd of their original volume at 0°C for every 1°C change in temperature when pressure remains constant?
(a) Joule's law (b) Boyle's law
(c) Gay-Lussac law (d) Charle's law
[SSC-JE : 2007]

1.2 Zeroth law of thermodynamics defines:
(a) internal energy (b) enthalpy
(c) temperature (d) pressure
[SSC-JE : 2008]

1.3 The term NTP stands for
(a) Nominal temperature and pressure
(b) Natural temperature and pressure
(c) Normal temperature and pressure
(d) Normal thermodynamics practice
[SSC-JE : 2010]

1.4 Mixture of ice and water form a
(a) Closed system
(b) Open system
(c) Isolated system
(d) Heterogeneous system [SSC-JE : 2010]

1.5 When neither mass nor energy is allowed to cross the boundary of a system, it is then called:
(a) Open system (b) Isolated system
(c) Universe (d) Closed system
[SSC-JE : 2012]

1.6 In case of Boyle's law, if pressure increases by 1% the percentage decrease in volume is :
(a) $\frac{1}{101}\%$ (b) $\frac{100}{101}\%$
(c) $\frac{1}{100}\%$ (d) 0% [SSC-JE : 2012]

1.7 The boiling and freezing points for water are marked on a temperature scale *P* as 130°P and –20°P respectively. What will be the reading on this scale corresponding to 60°C on Celsius scale?
(a) 60°P (b) 70°P
(c) 90°P (d) 110°P
[SSC-JE : 2014 (E)]

1.8 Which of the following is an extensive property?
(a) temperature (b) pressure
(c) density (d) enthalpy
[SSC-JE : 2014 (M)]

1.9 The sequence of process that eventually returns the working substance to its original state, is known as _____.
(a) Event
(b) Thermodynamic cycle
(c) Thermodynamic property
(d) None of these
[SSC-JE (Forenoon) 1.3.2017]

1.10 According to kinetic theory of gases, at absolute zero _____.
(a) Specific heat of molecules reduces to zero
(b) Kinetic energy of molecules reduces to zero
(c) Volume of gas reduce to zero
(d) Pressure of gas reduce to zero
[SSC-JE (Forenoon) 1.3.2017]

1.11 According to Gay-Lussac's law for perfect gases, the absolute pressure of given mass varies directly as _____.
(a) Temperature
(b) Absolute temperature
(c) Absolute temperature, if volume remains constant
(d) Product of absolute temperature and volume
[SSC-JE (Forenoon) 1.3.2017]

7.25	(b)	7.26	(d)	7.27	(d)	7.28	(d)	7.29	(d)	7.30	(b)	7.31	(d)	7.32	(a)
7.33	(d)	7.34	(b)	7.35	(c)	7.36	(c)	7.37	(a)	7.38	(d)	7.39	(b)	7.40	(d)
7.41	(c)	7.42	(b)	7.43	(a)	7.44	(d)	7.45	(b)	7.46	(b)	7.47	(a)	7.48	(c)
7.49	(d)	7.50	(b)	7.51	(d)	7.52	(d)	7.53	(a)	7.54	(a)	7.55	(a)	7.56	(b)
7.57	(d)	7.58	(d)	7.59	(a)	7.60	(a)	7.61	(a)	7.62	(a)	7.63	(b)	7.64	(d)
7.65	(d)	7.66	(a)	7.67	(d)	7.68	(b)	7.69	(a)	7.70	(c)	7.71	(b)	7.72	(d)
7.73	(c)	7.74	(a)	7.75	(c)	7.76	(c)	7.77	(b)	7.78	(a)	7.79	(d)	7.80	(c)
7.81	(b)	7.82	(c)	7.83	(b)	7.84	(b)	7.85	(b)	7.86	(c)	7.87	(d)	7.88	(a)
7.89	(a)	7.90	(a)	7.91	(d)	7.92	(c)	7.93	(c)	7.94	(a)	7.95	(c)	7.96	(d)
7.97	(a)	7.98.	(a)	7.99	(d)	7.100	(d)	7.101	(b)	7.102	(d)	7.103	(a)	7.104	(c)
7.105	(a)	7.106	(d)	7.107	(a)	7.108	(c)	7.109	(b)	7.110	(b)	7.111	(b)	7.112	(b)
7.113	(a)	7.114	(a)	7.115	(d)	7.116	(b)	7.117	(a)	7.118	(a)				

Explanations Thermodynamics

1. Basic Concepts & Zeroth Law of Thermodynamics

1.1 (d)

According to Charle's law, the pressure remains constant.

i.e., $V \propto T$

$$\frac{V_2}{V_1} = \frac{T_2}{T_1}$$

$$\frac{\Delta V}{V_1} = \frac{\Delta T}{T_1}$$

$$\Rightarrow \quad \frac{\Delta V}{V_1} = \frac{1}{273}$$

1.2 (c)

The temperature is associated with the ability to distinguish hot from cold.

The zeroth law is a consequence of thermal equilibrium and allows us to conclude that temperature is a well defined physical quantity.

1.3 (c)

The term NTP stands for normal temperature and pressure. NTP is defined as air at 20°C (293.15K) and 1 atm (101.325 kPa) pressure.

Note: STP stands for standard temperature and pressure and defined for air at 0°C temperature and 1 bar pressure.

1.4 (d)

- A homogeneous system is defined as the one whose chemical composition and physical properties are the same in all parts of the system, or change continuously from one point to another.
- A heterogeneous system is defined as one consisting of two or more homogeneous bodies (phases). Each phase is separated from other phases by interfaces or, boundaries and in passing over such a boundary the chemical composition of the substance or its physical properties abruptly change. An example of heterogeneous system is water with ice floating in it. This system has two homogeneous bodies, water and ice.

1.5 (b)

Isolated system is one in which there is no interaction between the system and surrounding whether it is mass or energy.

1.6 (b)

Boyle's law states that the absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remains unchanged within a closed system.

i.e. $P \propto \frac{1}{V}$ or $PV = k$

or, $P_1 V_1 = P_2 V_2$

$$P_1 V_1 = 1.01 P_1 V_2$$

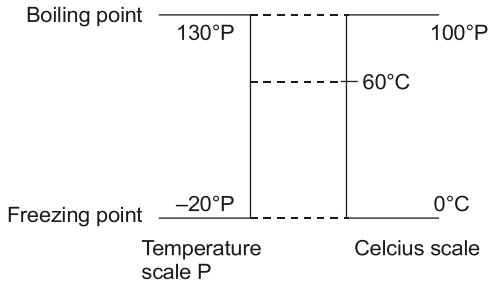
$$V_2 = \frac{1}{1.01} V_1 = \frac{100}{101} V_1$$

$$\% \text{ decrease in volume} = \frac{V_1 - V_2}{V_1} \times 100$$

$$= \frac{V_1 - \frac{100}{101} V_1}{V_1} \times 100 = \frac{100}{101}\%$$

1.7 (b)

Method-I



Let us have a scale :

$$°P = a\,°C + b$$

$$130 = a(100) + b$$

$$-20 = a(0) + b$$

$$150 = a(100)$$

$$\Rightarrow \quad °P = 1.5\,(°C) - 20$$

$$°P = 1.5 \times (60) - 20$$

$$= 90 - 20$$

$$°P = 70$$

Method-II

According to zeroth law,

$$\left(\frac{t - t_F}{t_B - t_F}\right)_{°C} = \left(\frac{t - t_F}{t_B - t_F}\right)_{°P}$$

$$\frac{60 - 0}{100 - 0} = \frac{t - (-20)}{130 - (-20)}$$

$$\frac{3}{5} = \frac{t + 20}{150}$$

$$\Rightarrow \quad t = 70°P$$

1.8 (d)

Enthalpy is an extensive property.

Extensive properties are those which depend upon the mass of the system.

1.9 (b)

The sequence of process that eventually returns the original state is known as thermodynamic cycle. It may also be defined as series of state changes such that the final state is identical with initial state.

1.10 (b)

Absolute zero is the point where all the molecules have no kinetic energy.

According to Kinematic theory of gases,

$$C_{rms} = \sqrt{\frac{3RT}{M}}$$

where, C_{rms} = Root mean square velocity of molecules

R = Characteristic gas constant

T = Temperature

M = Molecular weight

When temperature is zero, C_{rms} becomes zero when velocity is zero then kinetic energy of molecules is zero as kinetic energy is function of velocity.

1.11 (c)

According to Gay-Lussac's law for perfect gases, at constant volume the absolute pressure of given mass varies directly proportional to absolute temperature.

1.12 (d)

Three states of matter are distinguished with respect to molecules by character motion of molecules. In other words, it can also be defined as how the molecules of matter move.

Example: Motion of molecules in gas is more than that of liquids and solids.

1.13 (b)

Avogadro's law states that equal volume of all gases at the same temperature and pressure have the same number of molecules.

1.15 (a)

The properties which depends upon mass is called extensive properties. Example: Volume, entropy, enthalpy etc.

CHAPTER 4

Paper - I : Objective

Power Plant Engineering

1. Steam Power Plant

1.1 Thermal plant works on :
(a) Carnot cycle (b) Joule cycle
(c) Rankine cycle (d) All the above
[SSC-JE : 2009]

1.2 The recommended cycle for a steam power plant is
(a) Brayton cycle (b) Rankine cycle
(c) Carnot cycle (d) Otto cycle
[SSC-JE : 2011]

1.3 For the same maximum temperature in the cycle, the average temperature of heat addition of a Rankine cycle compared to that of Carnot cycle is-
(a) Same (b) not related
(c) higher (d) lower
[SSC-JE : 2015]

1.4 The difference between the temperature of the superheated steam and the liquid vapour saturation temperature at the corresponding pressure is known as-
(a) the extent of superheat
(b) the limit of superheat
(c) the approach of superheat
(d) the degree of superheat
[SSC-JE : 2015]

1.5 If a re-heater is added to a Rankine cycle, then usually:
(a) the net work and efficiency decreases
(b) the net work increases and efficiency remains same
(c) the net work and efficiency increases
(d) the net work remains same and efficiency increases
[SSC-JE : 2015]

1.6 In a cross compound steam engine _____.
(a) one high and one low pressure cylinder are set side by side, driving the same shaft, cranks being set 90° apart
(b) two cylinders are centered on the same piston rod, the L.P. cylinder being placed nearest the crankshaft
(c) two cylinders are set at 90°, usually to save floor space
(d) None of these
[SSC-JE : (Forenoon) 2.3.2017]

1.7 Which combination of the following statements is correct?
The incorporation of re-heater in a steam power plant
A. Always increases the thermal efficiency of the plant
B. Always increases the dryness fraction of steam at condenser inlet
C. Always increases the main temperature of heat addition
D. Always increases the specific work output
(a) A and D only (b) B and D only
(c) A, C and D only (d) A, B, C and D
[SSC-JE : (Forenoon) 2.3.2017]

1.8 The overall efficiency of thermal power plant is _____.
(a) Boiler efficiency, turbine efficiency and generator efficiency
(b) Boiler efficiency, turbine efficiency, generator efficiency and gas cycle efficiency
(c) Carnot cycle efficiency
(d) Regenerative cycle efficiency
[SSC-JE : (Forenoon) 2.3.2017]

1.9 The concept of regeneration is used in which cycles?
(a) Rankine and Stirling
(b) Stirling and Ericsson

Explanations **Power Plant Engineering**

1. Steam Power Plant

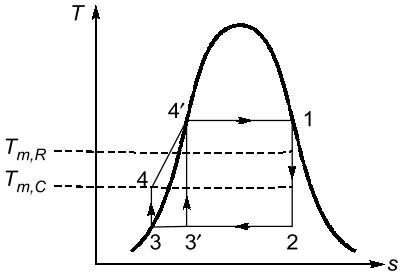
1.1 **(c)**

Thermal plant works on Rankine cycle, i.e. steam power cycle. However if gas turbine power plant is used, it works on Brayton's cycle.

1.2 **(b)**

The recommended cycle for a steam power plant is Rankine cycle.

1.3 **(d)**

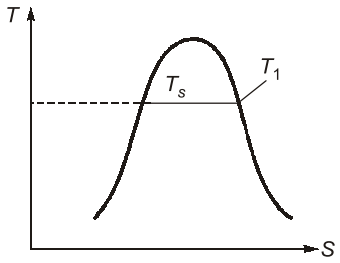


From this *T-S* diagram, 1-2-3′-4′-1 represents Carnot cycle.

1-2-3-4-4′-1 represents Rankine cycle.

So, mean (average) temperature of heat addition of a Rankine cycle is lower than that of Carnot cycle, when both cycle have same maximum temperature.

1.4 **(d)**



As shown in the *T-S* diagram, the difference between the temperature of the superheated steam and the liquid vapour saturation temperature ($T_1 - T_s$) at the corresponding pressure is known as the degree of superheat.

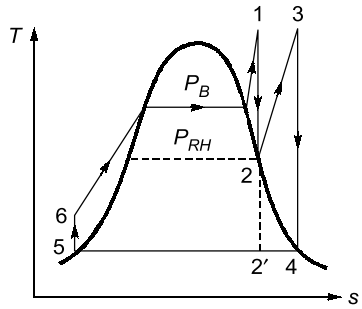
1.5 **(c)**

The main purpose of reheating is to avoid excess moisture at exit of turbine to protect the turbine blades. But it need not to improve the cycle efficiency of the cycle. That will depend upon the mean temperature of heat addition. There are dozons of examples that show a case where the reheat cycle efficiency is less than that without reheat.

$\Rightarrow \eta_{cycle} \propto$ Mean temperature of heat addition

So, it can be concluded that the cycle η can increase or decrease after reheating depending upon mean temperature of heat addition.

The net work in reheated cycle increases.



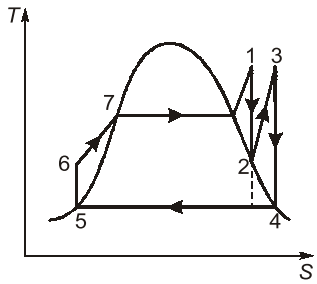
Here, on assuming mean temperature to increase, η increase.

1.6 **(a)**

Cross compound steam engine: Steam is expanded in two or more stages. One high pressure and one low pressure cylinder are set side by side, driving the same shaft. Exhaust from high pressure cylinder passes directly into low pressure cylinder.

1.7 **(b)**

Effect of using Reheater:



$W_{turbine} \uparrow$

W_{pump} = Constant

W_{net} $(W_T - W_P) \uparrow$

Heat supplied ↑ Heat rejected ↑

Mean temperature of heat addition - may increase or decrease

Mean temperature of heat rejection - constant

Efficiency - may increase or decrease

Dryness fraction of steam at condenser inlet - increases.

1.8 (a)

$$\eta_{overall} = \eta_{boiler} \times \eta_{turbine} \times \eta_{generator}$$

1.9 (*)

The regeneration can be incorporated in Rankine cycle, Stirling cycle, Ericsson cycle and Brayton cycle.

1.10 (d)

Anthracite has highest calorific value among given options. It has highest carbon content. It has the highest energy density of all types of coals and is highest ranking of coal.

1.11 (d)

Dry saturated state vapour means all the mixture is in the form of vapour

$$\text{Dryness fraction} = \frac{m_v}{m_v + m_l}$$

Here, m_l = Mass of liquid = 0

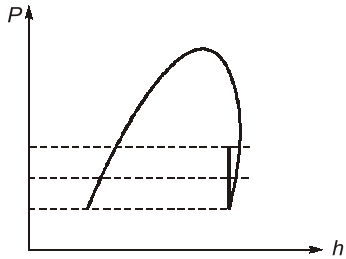
$$\therefore \quad \text{Dryness fraction} = \frac{m_v}{m_v} = 1 = 100\%$$

1.12 (c)

Air entering the water is unsaturated and as it comes in contact with water spray, water continues to evaporate till the air becomes saturated. So, the minimum temperature to which water can be cooled is the adiabatic saturation or wet bulb temperature (*wbt*) of atmosphere air.

In cooling tower. It use the evaporation of water to remove heat and cool the working fluid to near the wet bulb temperature.

1.13 (a)



Throttling means enthalpy will be same in both the states atmospheric pressure is greater than (5 – 10 kg/(cm)^2).

So, dry saturated steam becomes wet.

1.14 (a)

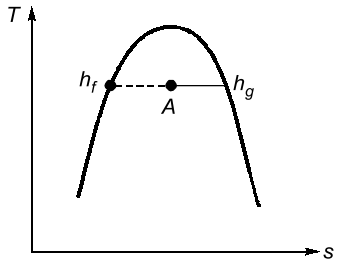
An ideal regenerative cycle is the one in which the condensate leaving from pump enters into the turbine (in which already steam is flowing) in counter flow direction. Thus, it is possible to heat the feed water to steam temperature at inlet to turbine. In this way the temperature at which heat is added becomes equal to a single temperature as in the case of carnot cycle. Thus, efficiencies of ideal regenerative cycle and that of carnot cycle are equal.

1.15 (d)

Fill or deck, is a medium used in cooling tower to increase the wetted surface area of the lower. Increased wetted surface area allows for maximum contact between the air and water, which allows for greater evaporation rate.

1.16 (a)

Let point A represent the state of wet steam with dryness fraction x.



Now, actual enthalpy of evaporation means the enthalpy required for converting wet steam to saturated steam can be given by

$$h_{fg,\,actual} = x(h_g - h_f) = xh_{fg}$$

1.17 (d)

Steam engine operates on Rankine cycle.

The Rankine cycle is an idealized thermodynamic cycle of a heat engine that converts heat into mechanical work while undergoing phase change.

1.18 (a)

In cooling tower water is cooled by the process of condensation. Condensation is change of physical state of matter from gas phase into liquid phase and is reverse of vaporization.

1.19 (a)

The Carnot cycle is the most efficient cycle. The efficiency of Rankine cycle can be increased by adding more number of regenerators.

- The limit or improvement made by regeneration stage seems to be that we can

CHAPTER 6

Paper - I : Objective

Theory of Machines

1. Simple Mechanisms

1.1 A kinematic pair consists of
(a) pair of elements having line or point contact
(b) pair of elements having surface contact
(c) two elements that permit relative motion
(d) two elements which are mechanically held together
[SSC-JE : 2007]

1.2 A simple mechanism has:
(a) 1 link (b) 2 link
(c) 3 link (d) 4 link
[SSC-JE : 2010]

1.3 A universal joint is an example of:
(a) Lower pair (b) Higher pair
(c) Rolling pair (d) Sliding pair
[SSC-JE : 2010]

1.4 The number of links L and the number of pairs in a kinematic chain conform to the relation
(a) $L = p - 4$ (b) $L = 2p - 4$
(c) $L = 2p + I$ (d) $L = 2(p - I)$
[SSC-JE : 2011]

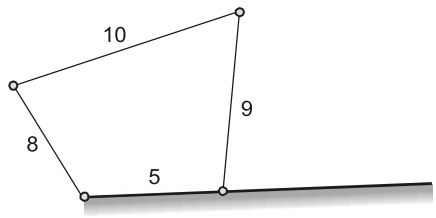
1.5 A ball and socket joint forms a :
(a) Rolling pair (b) Sliding pair
(c) Spherical pair (d) Turning air
[SSC-JE : 2012]

1.6 In a kinematic chain, the minimum number of kinematic pairs required is-
(a) one (b) two
(c) three (d) four
[SSC-JE : 2013]

1.7 The relation between the number of links (L) and number of pair (P) is :
(a) $L = 2P - 3$ (b) $L = 2P - 2$
(c) $L = 2P - 4$ (d) $L = 3 - 2P$
[SSC-JE : 2014 (M)]

1.8 The crank shaft turning in a journal bearing forms a :
(a) turning pair (b) sliding pair
(c) rolling pair (d) helical pair
[SSC-JE : 2014 (E)]

1.9 Figure shows a four bar chain and the number indicates the respective link lengths in cm. The type of the mechanism is known as :



(a) slider crank (b) double crank
(c) crank rocker (d) double rocker
[SSC-JE : 2014 (E)]

1.10 The contact between cam and follower is to form *a*:
(a) lower pair (b) higher pair
(c) sliding pair (d) rolling pair
[SSC-JE : 2014 (E)]

1.11 Quick return mechanism is an inversion of _____.
(a) Four bar chain
(b) Single slider crank chain
(c) Double slider crank chain
(d) Crossed slider crank chain
[SSC-JE (Forenoon) 1.3.2017]

1.12 The following is the inversion of slider crank mechanism
A. Whitworth quick return mechanism
B. Hand pump
C. Oscillating cylinder engine
(a) only A (b) only B
(c) only C (d) A, B and C
[SSC-JE : (Forenoon) 2.3.2017]

1.13 Which of the following is NOT classified as types of link?
(a) Rigid link (b) Flexible link
(c) Fluid link (d) None of these
[SSC-JE : (Afternoon) 22.1.2018]

1.14 What kind of contact can be established for a higher pair?
(a) Point contact (b) Surface contact
(c) No contact (d) None of these
[SSC-JE : (Afternoon) 22.1.2018]

1.15 How many degrees of freedom exist in a free body in space?
(a) 3 (b) 4
(c) 5 (d) 6
[SSC-JE : (Afternoon) 22.1.2018]

1.16 A mechanism can be classified into a structure when the degree of freedom is _____.
(a) 0 (b) 1
(c) 2 (d) 3
[SSC-JE : (Afternoon) 22.1.2018]

1.17 Choose the option which does NOT belong to the category of simple machine
(a) Spring (b) Screw
(c) Wedge (d) Pulley
[SSC-JE : (Forenoon) 23.1.2018]

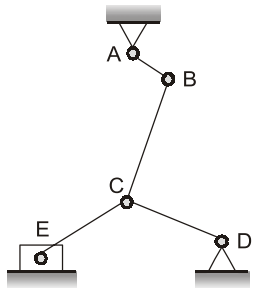
1.18 The Scotch yoke mechanism is the inversion of _____.
(a) four bar link chain
(b) double slider crank chain
(c) single slider crank chain
(d) None of these
[SSC-JE : (Afternoon) 23.01.2018]

1.19 Which of the following is NOT the inversion of single slider crank chain?
(a) Pendulum pump
(b) Whitworth quick return motion mechanism
(c) Oscillating cylinder engine
(d) Elliptical trammel
[SSC-JE : (Afternoon) 23.01.2018]

1.20 The number of joints (j) which constitutes a kinematic chain can be expressed in terms of number of links (l) as _____.
(a) $j = \frac{3}{4}l - 2$ (b) $j = \frac{3}{4}l + 2$
(c) $j = \frac{3}{2}l - 2$ (d) $j = l - \frac{3}{2}$
[SSC-JE : (Afternoon) 23.01.2018]

1.21 Which of the following will lead to the formation of higher pair?
(a) Sliding pair (b) Turning pair
(c) Rolling pair (d) None of these
[SSC-JE : (Afternoon) 23.01.2018]

1.22 What is the degree of the mechanism shown below?



(a) 1 (b) 2
(c) 3 (d) 4
[SSC-JE : (Afternoon) 23.01.2018]

1.23 Which kind of pair can attachment of a car mirror be classified into?
(a) Rolling pair (b) Sliding pair
(c) Spherical pair (d) Screw pair
[SSC-JE : (Forenoon) 24.01.2018]

1.24 Kinematic chain is known as mechanism when_____.
(a) none of the link is fixed
(b) one link is fixed
(c) two links are fixed
(d) all of the links are fixed
[SSC-JE : (Forenoon) 24.01.2018]

1.25 Which law states that the length of the shortest and the longest links should not be greater than the sum of the other two links in the four bar mechanism?
(a) Grashof's law (b) Grubler's law
(c) Whitworth's law (d) Oldham's law
[SSC-JE : (Afternoon) 24.01.2018]

7. Dynamics of Machines, Turning Moment, Flywheel

7.1	(d)	7.2	(b)	7.3	(d)	7.4	(b)	7.5	(b)	7.6	(a)	7.7	(a)	7.8	(b)
7.9	(d)	7.10	(b)	7.11	(*)	7.12	(b)	7.13	(c)	7.14	(d)	7.15	(b)	7.16	(a)
7.17	(d)	7.18	(a)	7.19	(d)	7.20	(b)	7.21	(a)	7.22	(c)	7.23	(d)	7.24	(b)
7.25	(a)	7.26	(d)	7.27	(a)	7.28	(a)	7.29	(a, d)	7.30	(c)	7.31	(d)	7.32	(d)
7.33	(c)	7.34	(b)	7.35	(a)	7.36	(a)	7.37	(a, b)	7.38	(c)	7.39	(a)	7.40	(d)
7.41	(d)	7.42	(b)	7.43	(d)										

8. Governors

8.1	(b)	8.2	(*)	8.3	(c)	8.4	(d)	8.5	(d)	8.6	(d)	8.7	(b)	8.8	(d)
8.9	(c)	8.10	(a)	8.11	(d)	8.12	(a)	8.13	(b)	8.14	(b)	8.15	(d)	8.16	(b)
8.17	(b)	8.18	(b)	8.19	(c)	8.20	(b)	8.21	(b)	8.22	(a)	8.23	(a)	8.24	(a)
8.25	(a)	8.26	(c)	8.27	(d)	8.28	(d)	8.29	(c)	8.30	(b)	8.31	(b)	8.32	(d)
8.33	(d)	8.34	(c)	8.35	(c)	8.36	(b)	8.37	(b)	8.38	(b)	8.39	(c)		

9. Vibrations

9.1	(d)	9.2	(b)	9.3	(c)	9.4	(c)	9.5	(d)	9.6	(b)	9.7	(b)

10. Balancing

10.1	(b)	10.2	(a, c)	10.3	(d)

11. Gyroscope

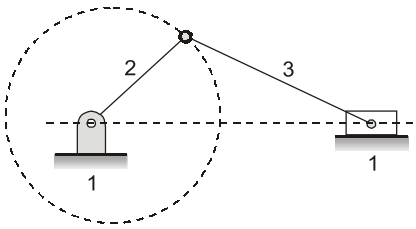
11.1	(a)

Explanations Theory of Machines

1. Simple Mechanisms

1.1 (c)

A kinematic pair is simply a pair of a joint of two links having relative motion between them.
For example: Single side crank mechanism



Link 2 rotates w.r.t. link 1: Link 1, 2 are an example of kinematic pair.

1.2 (d)

- Mechanism: when one link of a kinematic chain is fixed and is used to transmits motion then the chain is known as mechanism.
- It is of simple and compound mechanism.
- A mechanism with four links is known as simple mechanism and mechanism with more than four link is known as compound mechanism.

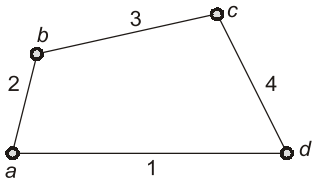
1.3 (a)

- Hooke's joint: an example of lower pair is also known as universal joint.
- It is used to connect two non-parallel and intersecting shafts.
- It is used for shafts with angular misalignment.

- A common application of this joint is in automobile where it is used to transmit power from the gear box (engine) to rear axle.
- A lower pair is an ideal joint that constrains contact between a surface in the moving body to a corresponding surface in the fixed body.
- A lower pair is one in which there occurs a surface or area contact between two members e.g. nut and screw, universal joint used to connect two propeller shaft.

1.4 (b)

For four bar mechanism:



l = Number of link

p = Number of pairs

l = 4 (as seen in figure)

p = 4 (as seen in figure)

By checking each equation:

$$L = 2p - 4$$

$$4 = 2 \times 4 - 4 = 4$$

Hence option (b) is correct.

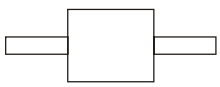
Note: For a four link chain mechanism, relationship between the number of links l and number of pairs p can be established as

$$l = 2p - 4$$

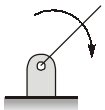
1.5 (c)

Kinematic pairs according to nature of relative motion.

(a) Sliding pair - two link have sliding motion relative to each other eg: rectangular rod in a rectangular hole in a prism.



(b) Turning pairs - when one link has turning or revolving motion relative to other.



(c) Rolling pair - relative motion relative to each other. Eg: a rolling on flat surface, ball and roller bearing etc.

(d) Screw pair (helical pair) - two mating links have turning as well as sliding motion between them.
Eg: Lead screw and the nut of a lathe in a screw pair.

(e) Spherical pair: When one link in the form of a sphere turns inside a fixed link, it is a spherical pair.
Eg: Ball and socket joint.

1.6 (c)

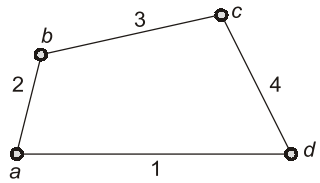
In a kinematic chain, the minimum number of kinematic pairs required is three, eg. cam and follower in which two lower pair and one higher pair forms the kinematic chain.

1.7 (c)

For four bar mechanism (assume) relationship between number of link 'l' and number of pairs (p) can be established as

$$l = 2p - 4$$

Proof: Take a 4-bar mechanism.



l = Number of links = 4

p = Number of pairs = 4

If each link is assumed to form pairs with two adjacent links then

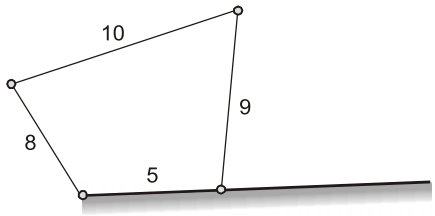
$$l = 2 \times 4 - 4 = 4$$

1.8 (a)

When one link has a turning or revolving motion relative to the other, they constitute a turning or revolving pair. The crankshaft turning in a journal bearing forms a turning pair.

1.9 (b)

Double-crank



Length of shortest link = 5 cm
Length of longest link = 10 cm

$$s + l \leq p + q$$
$$5 + 10 \leq 8 + 9$$

So, here the sum of the shortest and the longest links is less than the sum of the other two links. Also, the shortest link is fixed. Hence, this mechanism is double crank mechanism.

1.10 (b)

Kinematic pairs according to nature of contact.

(i) Lower pair: Surface/area contact.
Eg: Nut turning is screw, shaft rotating in a bearing, all pairs or a slider-crank mechanism, universal joint etc.

(ii) Higher pair: a point of line contact
Eg: wheel rolling on a surface, command follower pair, tooth gear, ball and roller bearing etc.

1.11 (b)

Inversion of single slider crank chain are
1st inversion: (Link-1 fixed)
1. Reciprocating engine
2. Reciprocating compressor

2nd inversion: (Link-2 fixed) i.e. crank is fixed
1. Withworth quick return mechanism
2. Rotary engine

3nd inversion: (Link-3 fixed)
1. Oscillating cylinder engine
2. Crank and slotted-level mechanism

4th inversion (Link-4) i.e., slider is fixed
1. Hand pump or ball engine

1.12 (d)

Inversion of single slider crank chain
1st inversion
1. Reciprocating engine
2. Reciprocating compressor

2nd inversion
1. Withworth quick return mechanism
2. Rotary engine

3nd inversion
1. Oscillating cylinder engine
2. Crank and slotted-level mechanism

4th inversion
1. Hand pump

1.13 (d)

Based on ends on which revolute or turning pairs can be placed.
1. Binary link 2. Ternary link
3. Quaternary link

Based on rigidity, kinematic links are classified into three types
1. Rigid link
2. Flexible link
3. Fluid link

1.14 (a)

Kinematic pairs according to nature of contact
(i) Lower pair : Surface/area contact
Eg: Nut in screw, shaft in bearing, all pairs of slider-crank mechanism, Hook's joint.

(ii) Higher pair: Line/point contact
Eg: Cam and follower, tooth of gear bull and roller bearing etc.

1.15 (d)

In free body in 3D space, these exist 6 degree of freedom.
Three translational along axes x, y and z.
Three rotational about axes x, y and z.

1.16 (a)

- A redundant chain is one which does not allow any motion of a link relative to the other.
- If one of the links of a redundant chain is fixed it is known as a structure or a locked system.
- Degree of freedom of a structure or a locked system is zero.
- A structure with negative degree of freedom is known as superstructure.

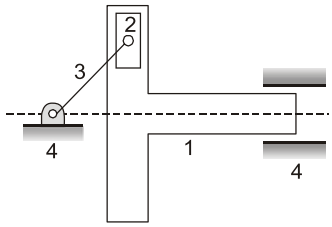
1.17 (a)

There are 6 basic simple machines:- lever, the wheel, the axle, the inclined plane, the wedge, pulley and the screw.

1.18 (b)

Double slider crank chain-
Inversion:
1. Elliptical trammel (1st)
2. Scotch yoke (2nd)
3. Oldham's coupling (3rd)

- Scotch yoke mechanism is inversion of double slider crank mechanism.



1.19 (d)

Single slider crank chain inversion

1st

(i). Reciprocating engine

(ii). Reciprocating compressor

2nd

(i). Withworth quick return mechanism

(ii). Rotary engine

3nd

(i). Oscillating cylinder engine

(ii). Crank and slotted-lever mechanism

4th

(i). Hand pump

Double slider crank chain-

Inversion:

(i). Elliptical trammel

(ii). Scotch yoke

(iii). Oldham's coupling

1.20 (c)

Number of joints = l and Number of links = j

According to Kutzbach criterion,

$$F = 3(l - 1) - 2j - h \quad \text{...(i)}$$

For kinematic chain, degrees of freedom = 1

Higher pair (h) = 0

From equation (i)

$$1 = 3(l - 1) - 2j$$

$$2j = 3l - 3 - 1$$

$$j = \frac{3l - 4}{2} = \frac{3l}{2} - 2$$

1.21 (c)

Kinematic pairs according to nature of relative motion:

(a) Sliding pair: sliding of slider

(b) Turning pair: Revolving motion of crank

(c) Rolling pair: Rolling wheel

(d) Screw pair: Lead screw and nut of lathe

(e) Spherical pair: Ball and socket joint

Rolling wheel has point contact with flat surface hence it also forms higher pair.

1.22 (a)

Total number of joints (j) = 7(6 revolute + 1 sliding)

Number of links (l) = 6

Degree of freedom of given mechanism

$$F = 3(l - 1) - 2j$$

$$= 3(6 - 1) - 2 \times 7$$

$$= 15 - 14 = 1$$

1.23 (c)

The attachment of car mirror can be classified into spherical pair.

Spherical pair: When two elements of a pair are connected in such a way that one element with spherical shape turns or revolves about the other fixed element. The pair formed is called a spherical pair.

Example: Ball and socket joint.

1.24 (b)

- When one of the links of a kinematic chain is fixed, it is known as a linkage or mechanism.
- We can obtain as many mechanisms as the number of links in kinematic chain by fixing in turn, different links in a kinematic chain. This method is called inversion of mechanisms.

1.25 (a)

Grashof's law which states that a four-bar mechanism has at least one revolving link if the sum of the length of the largest and shortest link is less than the sum of lengths of the other two links.

1.26 (c)

Kinematic pair cannot be classified on the basis of number of connected links.

They are mainly classified on the basis of following three criteria's.

1. Based on nature of contact between the pairing elements.
2. Type of mechanical constraint.
3. Type of relative motion between the elements of a pair.

1.27 (c)

A screw joint has a one degree of freedom kinematic pairs used in mechanisms. Screw joints provide single axis translation by utilizing the threads of the threaded rod to provide such translation.

CHAPTER 8

Paper - I : Objective

Machine Design

1. Design against Fluctuating Load

1.1 Fatigue of a component is due to :
(a) cyclic load (b) static load
(c) constant heating (d) collision
[SSC-JE : 2014 (E)]

1.2 Which strength of the material is to be considered for design of a ductile component under cyclic load?
(a) Ultimate strength
(b) Yield strength
(c) Endurance strength
(d) Fracture strength [SSC-JE : 2014 (E)]

1.3 Which of the following is not the correct procedure to increase the fatigue limit?
(a) cold working
(b) shot peening
(c) surface decarburization
(d) under-stressing
[SSC-JE : (Forenoon) 4.3.2017]

1.4 What should be the incremental factor for the number of shoes, if the engagement speed for the centrifugal clutch needs to be doubled?
(a) 0.5 (b) 1
(c) 2 (d) 4
[SSC-JE : (Afternoon) 22.1.2018]

1.5 The fatigue strength of the metallic material can be increased by which of the following features?
(a) Under stressing
(b) Overstressing
(c) Increasing the temperature
(d) Scratching the surfaces
[SSC-JE : (Afternoon) 25.01.2018]

2. Cotter and Knuckle Joint

2.1 A cotter joint is used to connect rods which are in:
(a) Compression only
(b) Tension and compression only
(c) Shear only
(d) Tension only
[SSC-JE : 2015]

3. Welded and Riveted Joint

3.1 In a single *V*-butt welds, the angle between edges is kept about:
(a) 20 to 40° (b) 40 to 60°
(c) 70 to 90° (d) 10 to 20°
[SSC-JE : 2012]

3.2 The thickness of a boiler plate is 16 mm, the diameter of rivet used in the boiler joint is:
(a) 24 mm (b) 28 mm
(c) 10 mm (d) 20 mm
[SSC-JE : 2012]

3.3 The shear strength, tensile strength and, compressive strength of a rivet joint are 100 N, 120 N and 150 N respectively. If strength of the unriveted plate is 200 N, the efficiency of rivet joint is :
(a) 60% (b) 75%
(c) 80% (d) 50%
[SSC-JE : 2012]

3.4 The shearing strength of a rivet in 50 N/mm^2. If the diameter of the rivet is doubled, then its shearing strength will be :
(a) 100 N/mm^2 (b) 200 N/mm^2
(c) 50 N/mm^2 (d) 300 N/mm^2
[SSC-JE : 2014 (E)]

Explanations Machine Design

1. Design against Fluctuating Load

1.1 (a)

Fatigue of a component is due to cyclic load. Fatigue occurs when a material is subjected to repeated loading and unloading.

Fatigue failure is common in transmission shaft, ball bearing, connecting rod, suspension spring.

1.2 (c)

Endurance strength is to be considered for design of a ductile component under cyclic load. The fatigue or endurance limit of a material is defined as the maximum amplitude of completely reversed stress that the standard specimen can sustain for an unlimited number of cycles without fatigue failure.

1.3 (c)

Fatigue limit of material can be increased by

(i) By applying residual compressive stress (under stress)
(ii) By surface finishing
(iii) By shot peening
(iv) Cold working

1.4 (c)

For doubling the engagement speed for the centrifugal clutch, number of shoes should be doubled.

Engagement speed: It indicate the speed at which centrifugal force acting on the mass of flyweights overcomes the force exerted by the tension springs that restrain them. So by doubling the number of shoes, centrifugal forces are doubled and so engagement speed.

1.5 (b)

Refer the explanation of Question 1.3.

2. Cotter and Knuckle Joint

2.1 (b)

Cotter joint is temporary fastening used connect rigidly two co-axial rods or bars which are either subjected to compressive load or tensile load.

Application:

1. Joint between piston rod and cross head of steam engine.
2. Joint between slide spindle and fork of valve mechanism.
3. Joint between piston rod and tail or pump rod.
4. Foundation bolt.

3. Welded and Riveted Joint

3.1 (b)

Welded joint are divided into two groups: butt joints and fillet joint.

Butt joints are defined as a joint between two components lying approximately in the same plane some examples are:

Square butt weld, single V-butt weld, U-butt weld, double, V - butt weld etc.

For single V - belt weld angle between edges are kept 40° to 60°.

3.2 (a)

Thickness of boiler plate,

$$t = 16 \text{ mm}$$

Using Unwin's equation,

Diameter of rivet (d) = $6\sqrt{t}$

$$= 6\sqrt{16} = 24 \text{ mm}$$

3.3 (d)

Shear strength, P_s = 100 N
Tensile strength, P_t = 120 N
Compressive strength, P_c = 190 N
Strength of unriveted plate, P = 200 N

Efficiency of riveted joint is defined as ratio of the strength of riveted joint to the strength of unriveted solid plate.

$$\eta = \frac{\text{Lowest of } P_s, P_t \text{ and } P_c}{P}$$

$$= \frac{100}{200} = 0.50 = 50\%$$

3.4 (b)

Shearing strength of rivet by

$$P_s = \frac{\pi}{4} d^2 \tau$$

where d = diameter of rivet (mm)

τ = permissible shear stress for rivet material (N/mm^2)

$$P_{s_1} = 50 \text{ N}$$

If diameter of rivet is doubled then

$$\frac{P_{s_2}}{P_{s_1}} = \frac{\frac{\pi}{4} d_2^{\,2} \cdot \tau}{\frac{\pi}{4} d_1^{\,2} \tau}$$

$$P_{s_2} = P_{s_1} \times \frac{(2d)^2}{d^2} = 50 \times 4$$

$$= 200 \text{ N}$$

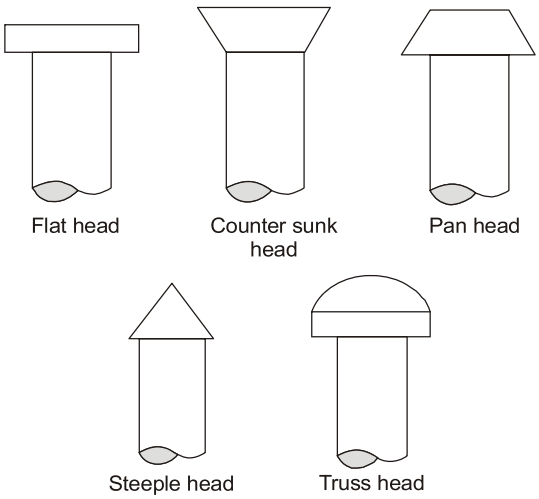
Note : Shearing strength is shearing resistance of rivet per pitch length and has units of Newton, while in question, units are given as N/mm^2.

3.5 (d)

- A rivet is specified by shank diameter of rivet (aka. Nominal diameter)

Note: Rivets and weld joints are permanent joint.

3.6 (c)



3.7 (a)

A metal ring used inside a butt welded joint to reinforce the joint and to prevent weld metal from entering the pipe at the joint.

3.8 (c)

$$\eta_{\text{tearing}} = \left[1 - \left(\frac{d_h}{p}\right)\right]$$

$$0.6 = 1 - \left(\frac{d_h}{p}\right)$$

$$\frac{d_h}{p} = 0.4$$

3.9 (d)

Failure may occur due to any one or more:

1. Shearing failure of rivet.
2. Shearing failure of plate.
3. Tensile failure of plate between two consecutive rivets.
4. Crushing failure of plate.
5. Tearing of plate in margin area.

3.10 (d)

Power transmitted by belt = $(T_1 - T_2)R\left(\frac{2\pi N}{60}\right)$

Where, T_1 = Tension on tight side

T_2 = Tension on loose side

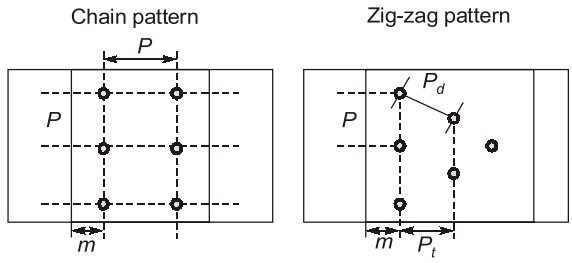
R = Radius of pulley

N = Speed of pulley (rpm)

3.11 (a)

- Power factor is ratio between active power and sum of active and reactive power.
- Welding unit has highly inductive load, having power factor below 0.5.

3.12 (c)



P = Pitch = Distance between centre of one rivet to centre of other in same row.

P_t = Transverse pitch/back pitch/ row pitch.

P_d = Diagonal pitch

3.13 (c)

Rivets are used in aircraft body because aircraft are mostly made of aluminium and its alloys and there are difficult to solder.

CHAPTER

10

Paper - I : Objective

Engineering Mechanics

1. System of Forces

1.1 Two Tensile forces, each of magnitude F are acting at a point perpendicular to each other, then their resultant force will be

(a) $\sqrt{2}\,F$ (b) Zero

(c) $\sqrt{F}$ (d) $\sqrt{2F}$

[SSC-JE : 2014 (M)]

1.2 If the x-component of a force is negative and the y-component is positive, the direction of that force must lie in the :

(a) Fourth quadrant (b) First quadrant

(c) Second quadrant (d) Third quadrant

[SSC-JE : 2014 (M)]

1.3 What are the equilibrium conditions to be satisfied for a particle applied with a system of non-coplanar, concurrent forces?

(a) $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma F_z = 0$ and $\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$

(b) $\Sigma F_x = 0$, $\Sigma F_y = 0$, and $\Sigma F_z = 0$

(c) $\Sigma F_x = 0$ and $\Sigma F_y = 0$

(d) $\Sigma F_x = 0$, $\Sigma F_y = 0$ and $\Sigma M_z = 0$

[SSC-JE : 2015]

1.4 A satellite is kept on moving in its orbit around the earth due to _____.

(a) centrifugal force

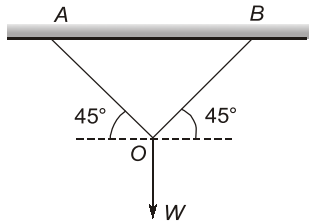
(b) centripetal force

(c) gravitational force

(d) resultant forces acting on satellite

[SSC-JE : (Forenoon) 2.3.2017]

1.5 Two wires *AO* and *BO* support a vertical load *W* at *O* as shown in figure below. The wires are of equal length and equal cross-sectional area. The tension in each wire is equal to:



(a) $W/2$ (b) W

(c) $\sqrt{2}W$ (d) $W/\sqrt{2}$

[SSC-JE : (Forenoon) 2.3.2017]

1.6 Ties are load carrying members which carry

(a) torsional loads

(b) axial compressive loads

(c) axial tension loads

(d) transverse loads

[SSC-JE : (Forenoon) 3.3.2017]

1.7 The forces which meet at one point and have their lines of action in different planes are called

(a) coplanar non-concurrent forces

(b) non-coplanar concurrent forces

(c) non-coplanar non-concurrent forces

(d) intersecting forces

[SSC-JE : (Forenoon) 4.3.2017]

1.8 An object having 10 kg mass weighs 9.81 kg on a spring balance. The value of 'g' at this place is

(a) 10 m/sec^2 (b) 9.81 m/sec^2

(c) 10.2 m/sec^2 (d) 9.75 m/sec^2

[SSC-JE : (Afternoon) 4.3.2017]

1.9 Two forces act at an angle of 120°. If the greater force is 50 N and their resultant is perpendicular to the smaller force, the smaller force is _____N.

(a) 20 (b) 25

(c) 30 (d) 35

[SSC-JE : (Afternoon) 4.3.2017]

1.10 What term is used for the combined effect of all the forces on a body?
(a) Load (b) Stress
(c) Strain (d) None of these
[SSC-JE : (Forenoon) 22.1.2018]

1.11 Which of the following load does not act on the considerable length of the beam?
(a) Uniformly distributed
(b) Triangular
(c) Point
(d) Uniformly varying
[SSC-JE : (Forenoon) 22.1.2018]

1.12 Choose the CORRECT option regarding the effect of forces acting on the body?
(a) Introduces internal stress
(b) Balance the other forces acting on it
(c) Retard its motion
(d) All option are correct
[SSC-JE : (Forenoon) 27.01.2018]

1.13 An insulated box containing 0.5 kg of a gas having c_v = 0.98 kJ/kgK fails from a balloon 4 km above the earth's surface. The temperature rise of the gas when the box hits the ground is
(a) 0 (b) 20 K
(c) 40 K (d) 60 K
[SSC-JE : (Forenoon) 29.01.2018]

1.14 The point of application of the resultant of all the forces which tends to cause rotation in the body about a certain axis known as _____
(a) center of gravity
(b) the point of metacentre
(c) point of suspension
(d) centre of percussion
[SSC-JE : (Forenoon) 29.01.2018]

1.15 The use of the D Alembert's principle is for _____
(a) determining the stresses in the truss
(b) stability of floating bodies
(c) reduction of problems of kinetics to equivalent statics problem
(d) design of safe structures
[SSC-JE : (Afternoon) 29.01.2018]

1.16 Two parallel forces equal in magnitude, opposite in direction and separated by a definite distance are said to from a/an:
(a) shear force (b) resultant
(c) equilibrant (d) couple
[SSC-JE : (Afternoon) 27.9.2019]

1.17 The forces whose line of action lie along the same line are known as:
(a) coplanar non-concurrent forces
(b) coplanar parallel forces
(c) coplanar concurrent forces
(d) collinear forces
[SSC-JE : (Afternoon) 27.9.2019]

1.18 Parallel forces have their lines of action:
(a) transverse to each other
(b) parallel to each other
(c) tangential to each other
(d) perpendicular to each other
[SSC-JE : (Forenoon) 27.10.2020]

1.19 A stone of mass 'm' at the end of a string of length 'l' is whirled in a vertical circle at a constant speed. What position of the stone shall result in the maximum tension in the string?
(a) Quarter-way down from the top
(b) Half-way down from the top
(c) At the bottom of the circle
(d) At the top-way of the circle
[SSC-JE : (Evening) 27.10.2020]

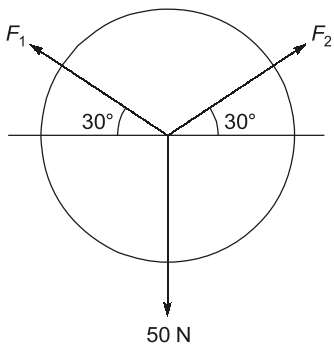
1.20 A 100 N force acts from a point P(0, 0, 0) to a point Q(1, 1, 1); then the force in, N, is represented as:

(a) $\left(\frac{100}{\sqrt{2}}\right)\left(\vec{i}+\vec{j}+\vec{k}\right)$ (b) $\left(\frac{100}{\sqrt{3}}\right)\left(\vec{i}+\vec{j}+\vec{k}\right)$

(c) $100\left(\vec{i}+\vec{j}+\vec{k}\right)$ (d) 100

[SSC-JE : (Afternoon) 14.11.2022]

1.21 If three forces are acting on the body as shown in the below figure and the body is in equilibrium, then the magnitude of forces F_1 and F_2 will be:

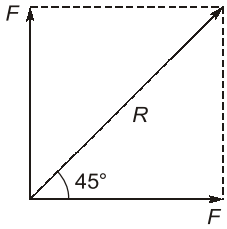


(a) F_1 = 50 N and F_2 = 50 N
(b) F_1 = 50 N and F_2 = 60 N

Explanations Engineering Mechanics

1. System of Forces

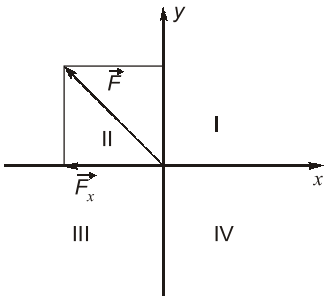
1.1 (a)



$$R = \sqrt{F^2 + F^2 + 2FF\cos 90°} = \sqrt{2F^2} = \sqrt{2}F$$

1.2 (c)

The direction of force must lie in the second quadrant.



1.3 (a)

For non-coplanar concurrent forces,
Equilibrium conditions are:

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$

and $\Sigma M_x = 0, \Sigma M_y = 0, \Sigma M_z = 0$

1.4 (a)

A satellite is kept on moving in its orbit around the earth due to centripetal force acting on satellite.

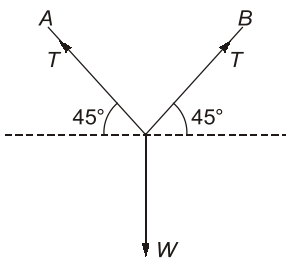
1.5 (d)

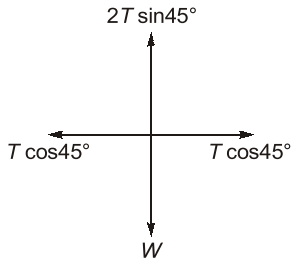
Method I

$$2T\sin 45° = W$$

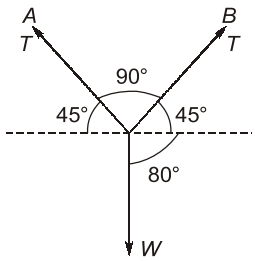
$$2T\frac{1}{\sqrt{2}} = W$$

$$\Rightarrow \quad T = \frac{W}{\sqrt{2}}$$





Method II



By Lami's theorem

$$\frac{W}{\sin 90} = \frac{T}{\sin(45+90)}$$

$$\frac{W}{1} = \frac{T}{\sin 135}$$

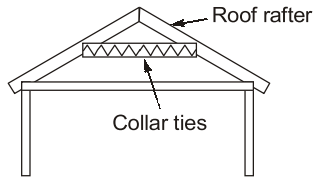
$$\Rightarrow \quad T = W\sin 135$$

$$T = W\sin 45$$

$$T = \left(\frac{W}{\sqrt{2}}\right)$$

1.6 (c)

Tie is structural member which holds other members in place like column, beams wall frames etc. Ties are usually subjected to tensile load and end moments.



1.7 (b)

Non-coplanar (means different plane) concurrent (mean intersects) forces are those forces which meet at one point and have their lines of action in different planes.

1.8 (a)

On spring balance: Weight = 9.18 kg
Object having mass = 10 kg of correct acceleration of gravity = 9.81 m/s^2

$$F = ma = 10 \times 9.81 = 98.1 \text{ N}$$

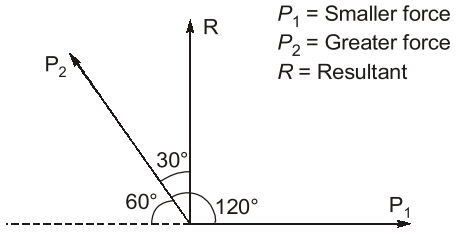
Now, for spring balance

$$F = \text{mass} \times g' = 9.81 \times g'$$

$$98.1 = 9.81 \times g'$$

$$g' = 10 \text{ m/s}^2$$

1.9 (b)



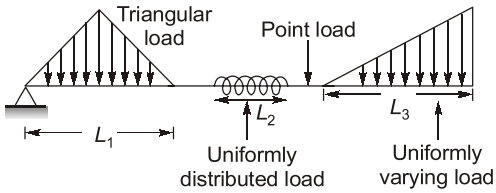
$$P_2 \cos 60^\circ = P_1$$

$$P_1 = 50 \times \frac{1}{2} = 25 \text{ N}$$

1.10 (a)

Load is used for the combined effect of all the forces on a body.

1.11 (c)



Point load is a concentrated load which does not act on considerable length of the beam.

1.12 (d)

The effect of forces acting on the body may be all of the following:

1. Introduce internal stress
2. Balance the other forces acting on it
3. Retard its motion

1.13 (c)

When ball hits the ground, assuming all the kinetic energy will be converted in the form of internal energy of balloon.

$$\frac{1}{2}mv^2 = mgh$$

$$v^2 = 2gh$$

$$\frac{1}{2}mv^2 = mc_V \Delta T$$

$$mgh = mc_V \Delta T$$

$$\Delta T = \frac{gh}{c_v} = \frac{9.81 \times 4000}{0.98 \times 10^3} = 40 \text{ K}$$

1.14 (d)

Centre of percussion is defined as point of application of the resultant of all the forces which tends to cause rotation in the body about a certain axis.

It can also be defined as that point at which a blow may be struck on a suspended body so that the reaction at the support is zero.

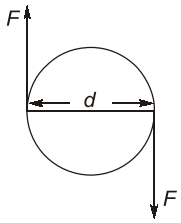
1.15 (c)

D'Alembert's principle states that the inertia forces and couples and external forces and torques on a body together gives statistical equilibrium.

Hence it is used for reduction of problem of kinetics to equivalent static problem.

1.16 (d)

A couple refers to two parallel forces that are equal in magnitude, opposite in sense and do not share a line of action. It is also called as force couple or pure moment.



Couple or moment = $F \times D$

1.17 (d)

Collinear forces are forces which have a common line of action, i.e., the line of action of the forces lie along a single straight line.

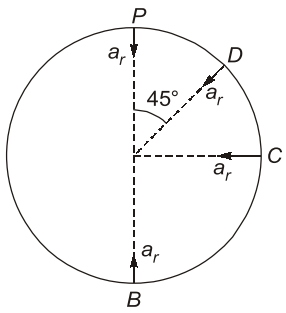
Eg., two people standing at the opposite ends of a rope and pulling on it.

1.18 (b)

Parallel forces have their line of action parallel to each other.

1.19 (c)

Given: V = Constant



$$a_r = \frac{V^2}{l} = \text{Constant}$$

Tension at A, $T_A = \frac{mV^2}{l} - mg$

Tension at B, $T_B = mg + \frac{mV^2}{l}$

Tension at C, $T_C = \frac{mV^2}{l}$

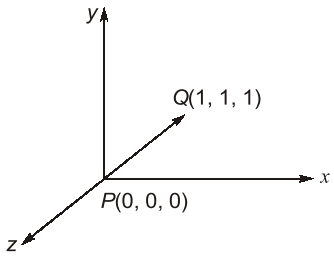
Tension at A, $T_A = \frac{mL^2}{l} - \frac{mg}{\sqrt{2}}$

Tension is maximum at bottom and minimum at top of the circle.

1.20 (b)

Unit vector in the direction of PQ is given by,

$$\hat{PQ} = \frac{\overrightarrow{PQ}}{\left|\overrightarrow{PQ}\right|} = \frac{\hat{i} + \hat{j} + \hat{k}}{\sqrt{3}}$$



∴ Therefore, the force will be represented as,

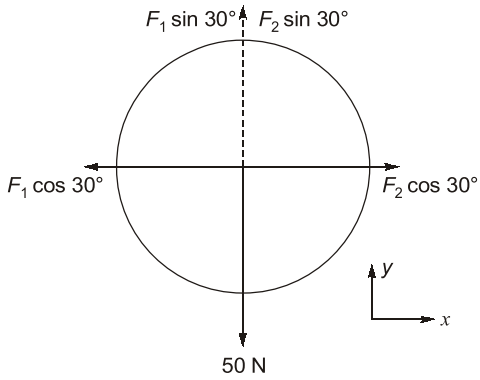
$$\vec{F} = 100(\hat{PQ})$$

$$\vec{F} = 100\left(\frac{\hat{i} + \hat{j} + \hat{k}}{\sqrt{3}}\right)$$

$$\vec{F} = \frac{100}{\sqrt{3}}(\hat{i} + \hat{j} + \hat{k})\ \text{N}$$

1.21 (a)

Taking the components of the forces in x and y directions, we get



$F_2 \cos 30° = F_1 \cos 30°$

$F_1 = F_2$ ...(i)

$F_1 \sin 30° + F_2 \sin 30° = 50$

$(F_1 + F_2)(1/2) = 5$

$F_1 + F_2 = 100$ ...(ii),

From equations (i) and (ii),

$F_1 = F_2 = 50$ N

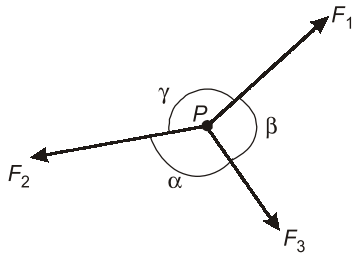
1.22 (a)

For non-concurrent force system equilibrium,

$\Sigma f_x = 0$; $\Sigma f_y = 0$; $\Sigma M = 0$

1.23 (d)

According to Lami's theorem, the three forces are related as



$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

2. Free Body Diagrams & Equilibrium Equations

2.1 (b)

Newton's second law of motion gives the measure of force.

First law : In an inertial reference frame, an object either remains at rest or continues to move at a constant velocity, unless acted upon by a net force.

Second law : In an inertial reference frame, the