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ESE 2018

Prelims Exam
Paper - II

MECHANICAL ENGINEERING

DETAILED SOLUTION (SET-D)

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Explanation of Mechanical Engg. Prelims Paper (ESE - 2018)

SET - D

1. The degrees of freedom of a SCARA robot are

(a) six (b) five

(c) four (d) three

Ans. **(c)**

2. Which one of the following devices produces incremental motion through equal pulses?

(a) AC servomotor (b) DC servomotor

(c) Stepper motor (d) Series motor

Ans. **(c)**

Sol. In a stepper motor, there are salient poles on rotor as well as stator. The motion of the rotor can be controlled by energizing the stator windings in a sequence, by using equal pulses.

3. A force of 400 N is required to open a process control valve. What is the area of diaphragm needed for a diaphragm actuator to open the valve with a control gauge pressure of 70 kPa?

(a) 0.0095 m^2 (b) 0.0086 m^2

(c) 0.0057 m^2 (d) 0.0048 m^2

Ans. **(c)**

Sol. $F = 400\ N$

Gauge pressure required (P) = 70kPa

$$= 70\times10^3\ \frac{N}{m^2}$$

Let the area of diaphragm be A.

From $P = \frac{F}{A}$

$$A = \frac{F}{P} = \frac{400}{70\times10^3} = 0.0057\ m^2$$

$$= 5.7 \times 10^{-3}\ m^2$$

4. A force of 10 kN is required to move a workpiece. What is the needed working pressure, if the piston diameter is 100 mm?

(a) 1.55 MPa (b) 1.46 MPa

(c) 1.27 MPa (d) 1.12 MPa

Ans. **(c)**

Sol.

Required force (F) = 10 kN

$= 10 \times 10^3\ N = 10^4 N$

Piston diameter (d) = 100 mm = 0.1m

Piston area $(A) = \frac{\pi d^2}{4} = 7.85\times10^{-3} m^2$

Let the needed working pressure is P.

From, $P = \frac{F}{A}$

$$P = \frac{10^4}{7.85\times10^{-3}} = 1.27\times10^6\ \frac{N}{m^2}$$

$P = 1.27$ MPa

5. If a workpiece is moved by 50 mm in 10 s by a piston of diameter 100 mm, the hydraulic liquid flow rate is nearly

(a) $3.00 \times 10^{-5}\ m^3/s$

(b) $3.93 \times 10^{-5}\ m^3/s$

(c) $4.74 \times 10^{-5}\ m^3/s$

(d) $5.00 \times 10^{-5}\ m^3/s$

SCROLL DOWN

Ans. **(b)**

Sol.

$$Q = A \times V$$

$$= \frac{\pi}{4} \times 100^2 \times \frac{50}{10} \times 10^{-9}$$

$$= 3.93 \times 10^{-5} \text{ m}^3/\text{s}$$

6. Which of the following are the basic building block elements for a mechanical system where forces and straight line displacements are involved without any rotation?

1. Spring
2. Dashpot
3. Mass
4. Moment of inertia

Select the correct answer using the code given below .

(a) 1, 2 and 4 (b) 1, 3 and 4

(c) 2, 3 and 4 (d) 1, 2 and 3

Ans. **(d)**

Sol. The basic building block elements for a mechanical system where forces and straight line displaements are involved, are

(1) Spring (k) [F = kx]

(2) Dashpot (B) $\left[F = B \cdot \frac{dx}{dt}\right]$

(3) Mass (m) $\left[F = m \cdot \frac{d^2x}{dt^2}\right]$

7. Consider the following statements regarding electromechanical devices :

1. A potentiometer has an input of rotation and an output of a potential difference.
2. An electric motor has an input of a potential difference and an output of rotation of a shaft.
3. A generator has an input of rotation of a shaft and an output of a potential difference.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol.

- A potentiometer has an input of displacement (either linear or angular), and an output of potential difference.
- For electric motor, the input is potential difference and output is rotation of shaft.
- For electric generator, the input is rotation of shaft and output is potential difference.

8. The indirect operation of solenoid valve in pneumatic circuit is designed to reduce

1. Valve size towards lowering the cost
2. Coil size and electrical power consumption
3. Response time

Which of the above is/are relevant to the context ?

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. **(d)**

9. Consider the following statements :

1. Robots only take permissible action.
2. All actions that are obligatory for robots are actually performed by them subject to ties and conflicts among available actions.
3. All permissible actions can be proved by the robot to be permissible and it can be explained in ordinary English.

Which of the above statements are correct?

(a) 1 and 3 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. According to Roboethics: A Navigating override

For a robot to be ethically correct, the following conditins must be satisfied.

– Robots only take permissible action

– All relative actions that are obligatory for robots are actually performed by them subjected to ties and confilicts among available action.

– All permissible (or obligatory or forbidden) actions can be proved by the robot to be permissible and all such proofs can be explained in ordinary english.

10. Consider the following statements relating to the term 'Robot Repeatability' :

1. It is a statistical term associated with accuracy in the action.
2. It is a measure of the ability of the robot to position the tool tip in the same place repeatedly.
3. It does not describe the error with respect to absolute coordinates.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. Robot repeatability has nothing to do with accuracy,

It is a measure of the ability of the robot to position the tool tip in the same place repeatedly.

11. Consider the following statements regarding homogeneous coordinate transformation matrix:

1. A homogeneous transformation matrix can be considered to consist of four sub-matrices.
2. The upper left 3 × 3 sub-matrix represents the position vector.
3. The upper right 3 × 1 sub-matrix represents the rotation matrix.
4. The lower left 1 × 3 sub-matrix represents perspective transformation.

Which of the above statements are correct ?

(a) 1 and 3 (b) 1 and 4
(c) 2 and 3 (d) 2 and 4

Ans. **(b)**

Sol. The general transformation matrix can be divided into four parts.

$$T = \begin{bmatrix} \text{Rotation Matrix } (3\times3) & \text{Translation vector } (3\times1) \\ \text{Perspective Transformation Matrix } (1\times3) & \text{Scale Factor } (1\times1) \end{bmatrix}$$

Directions :

Each of the next nineteen (19) items consists of two statements, one labeled as Statement I and the other as Statement II. Examine these two statements carefully and select the correct answer to these items using the code given below.

Code :

(a) Both Statement I and Statement II are individually true, and Statement II is the correct explanation of Statement I

(b) Both Statement I and Statement II are individually true, but Statement II is ***not*** the correct explanation of Statement I

(c) Statement I is true, but Statement II is false

(d) Statement I is false, but Statement II is

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true

12. **Statement I :**

A differential inverted U-tube manometer determines the difference in pressure between two points in a flow section to which it is connected.

Statement :

The sensitivity of an inclined gauge depends on the angle of inclination.

Ans. **(b)**

13. **Statement I :**

In four-bar chain, whenever all four links are used, with each of them forming a turning pair, there will be continuous relative motion between the two links of different lengths.

Statement II :

For a four-bar mechanism, the sum of the shortest and longest link lengths is not greater than the sum of remaining two links.

Ans. **(c)**

Sol. For a four bar mechanism to form, sum of three links should be more than longest link. For inversion purpose, the sum of largest and smallest should be less than the rest two.

14. **Statement I :**

When flow is unsteady, both normal and tangential components of acceleration will occur.

Statement II :

During unsteady flow, in addition to the change of velocity along the path, the velocity will also change with time.

Ans. **(d)**

Sol. Normal component will only occur in case of a curved streamline.

15. **Statement I :**

There exists a positive pressure difference between the inlet and throat of a venturi meter.

Statement II :

The coefficient of discharge of a venturi meter accounts for the non-uniformity of flow at both inlet and throat.

Ans. **(c)**

16. **Statement I :**

The phase of a substance is characterized by its distinct molecular arrangement which is homogeneous throughout and is separated from the others by easily identifiable boundary surfaces.

Statement II :

Phase change is not characterized on molecular structure and/or behavior of the different phases.

Ans. **(b)**

Sol. A phase is identified as having a distinct molecular arrangement that is homogeneous throughout and separated from the other by easily identifiable boundary surface.

Phase change is not concerned with the molecular structure and behaviour of different materials.

17. **Statement I :**

Non-viscous flow between two plates held parallel with a very small spacing between them is an example of irrotational flow.

Statement II :

Forced vortex implies irrotational flow.

Ans. **(c)**

Sol. Forced vortex is always rotational flow.

18. **Statement I :**

The air-fuel ratio employed in a gas turbine is around 60 : 1.

Statement II :

A lean mixture of 60 : 1 in a gas turbine is mainly used for complete combustion.

Ans. **(c)**

Sol. A high A/F ratio is required to maintain the temperature level dictated by turbine stresses.

19. **Statement I :**

The condenser in a steam power plant is always filled with a mixture of water, steam and air.

Statement II :

Slightly wet steam enters the condenser wherein the pressure is below the atmospheric conditions, causing some leakage of air through the glands and also the release of some air dissolved in the boiler feedwater.

Ans. **(a)**

20. **Statement I :**

In a pipeline, the nature of the fluid flow depends entirely on the velocity.

Statement II :

Reynolds number of the flow depends on the velocity, the diameter of the pipe and the kinematic viscosity of the fluid.

Ans. **(d)**

Sol. Nature of fluid flow depends on Reynolds number for a pipe flow.

21. **Statement I :**

The air-standard efficiency of Brayton cycle depends only on the pressure ratio.

Statement II :

For the same compression ratio, the air-standard efficiency of Brayton cycle is equal to that of Otto cycle.

Ans. **(b)**

Sol.
$$\eta_b = 1-\frac{1}{r_p^{\frac{\gamma-1}{\gamma}}}$$

$$\eta_b = 1-\frac{1}{r^{\gamma-1}}$$

$$\left(r_p^{\frac{\gamma-1}{\gamma}} = r^{\gamma-1} = T_1/T_2\right)$$

22. **Statement I :**

The energy of an isolated system is constant.

Statement II :

The entropy of an isolated system can increase but cannot decrease.

Ans. **(b)**

23. **Statement I :**

Rankine efficiency of a steam power plant increases in winter compared to summer.

Statement II :

The increase in Rankine efficiency is due to lower condenser temperature.

Ans. **(a)**

24. **Statement I :**

Direct condensers are more efficient than surface condensers.

Statement II :

In condenser, the momentum pressure drop opposes the frictional pressure drop.

Ans. **(d)**

Sol. Surface condenser has more vacuum efficiency than direct contact type condenser and finally it increase the thermal efficiency of the plant.

Purpose of condensor is to increase pressure drop to get more work output i.e. achievement of vacuum. This is possible with closed system (surface condenser) not with open system (direct contact condenser) so, statement I is wrong.

Friction pressure loss is the component of total pressure loss caused by viscous shear effect. It act always against direction of flow. Momentum pressure loss is loss due to change in velocity. Hence, momentum pressure loss oppose the friction pressure loss.

25. **Statement I :**

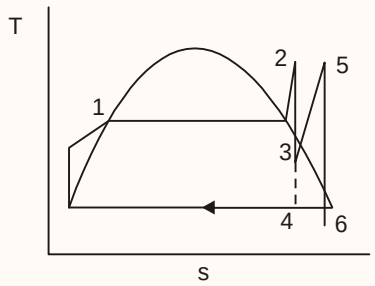
Reheating between the high-pressure and low-pressure turbines increases the turbine work output.

Statement II :

The constant pressure lines on T-s diagram diverge away from the origin.

Ans. **(b)**

Sol.



- Workoutput of the reheat cycle is increased as $(h_3 - h_4) < (h_5 - h_6)$
- The graph of h or T vs S is exponential in nature. Slope of h-s graph is equal to T at constant pressure.

  For control volume problems temperature is proportional to the pressure thus for two isobaric exponential curve one nearer to h will be at higher pressure.

  By above we conclude that constant pressure lines will diverge from one another in entropy diagram. It is thermodynamic fact.

26. **Statement I :**

If a boat, built with sheet metal on wooden frame, has an average density which is greater than that of water, then the boat can float in water with its hollow face upward but will sink once it overturns.

Statement II :

Buoyant force always acts in the upward direction

Ans. **(b)**

27. **Statement I :**

In air-blast injection, a separate compressor is used to create an air blast at a pressure of 6 MPa.

Statement II :

The solid injection system is heavier as it needs increasing the fuel pressure to 30 MPa.

Ans. **(c)**

Sol. In airblast injection, a seperate air compressor issued to inject the fuel into the cylinder. Since an air compressor is used this type of injection is more heavier than the solid injection system.

28. **Statement I :**

In air-conditioning, the atmospheric air (mixture of dry air and water vapour) can be considered

as mixture of two ideal gas.

Statement II :

In the temperature range used in air conditioning, the partial pressure of the water vapour is very low and it follows the ideal gas relation with negligible error.

Ans. **(a)**

29. **Statement I :**

A dynamically balanced system of multiple rotors on a shaft can rotate smoothly at the critical speeds of the system.

Statement II :

Dynamic balancing eliminates all the unbalanced forces and couples from the system.

Ans. **(a)**

30. **Statement I :**

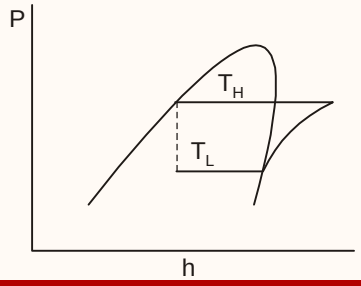
Referring to vapour compression refrigeration system, the coefficient of performance (COP) of a domestic refrigerator is less than that of a comfort air-conditioning plant.

Statement II :

In domestic refrigerator, the work required for pumping the same amount of heat is more than that in an air-conditioning plant because of greater difference between condenser and evaporator temperatures.

Ans. **(a)**

Sol. The P-h diagram of refrigerant,



COP of the refrigeration or air conditioner,

$$COP = \frac{T_L}{T_H - T_L}$$

In refrigerator, T_L is very low as compared to air conditioner and T_H is almost same in both the cases.

31. A 150 mm diameter shaft rotates at 1500 r.p.m. within a 200 mm long journal bearing with 150.5 mm internal diameter. The uniform annular space between the shaft and the bearing is filled with oil of dynamic viscosity 0.8 poise. The shear stress on the shaft will be

(a) 1.77 kN/m^2 (b) 2.77 kN/m^2

(c) 3.77 kN/m^2 (d) 4.77 kN/m^2

Ans. **(c)**

Sol.

$$\tau = \mu \times \frac{du}{dy}$$

$$= \mu \times \frac{r \times \omega}{dy}$$

$$= 0.08 \times 75 \times 10^{-3} \times \frac{2\pi \times 1500}{60 \times 0.25 \times 10^{-3}}$$

$$= 3769.9 \text{ N/m}^2$$

$$= 3.77 \text{ kN/m}^2$$

32. Which one of the following substances has constant specific heat at all pressures and temperature ?

(a) Mono-atomic gas (b) Di-atomic gas

(c) Tri-atomic gas (d) Poly-atomic gas

Ans. (a)

33. The shear stress τ_0 for steady, fully developed flow inside a uniform horizontal pipe with coefficient of friction f, density ρ and velocity v, is given by

(a) $\frac{f\rho v^2}{2}$ (b) $\frac{f\rho^2 v}{2}$

(c) $\frac{\rho^2 v}{2f}$ (d) $\frac{\rho v^2}{2f}$

Ans. (a)

Sol. $$\tau_0 = \frac{\rho f V^2}{8} = \frac{\rho f V^2}{2}$$

34. The total energy of each particle at various places in the case of a perfect incompressible fluid flowing in a continuous stream

(a) Keeps on increasing

(b) Keeps on decreasing

(c) Remains constant

(d) May increase or decrease

Ans. (b)

35. The normal stresses within an isotropic Newtonian fluid are related to

1. Pressure
2. Viscosity of fluid
3. Velocity gradient

Which of the above are correct ?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol. The normal stresses of an isotropic Newtonian fluid are related to pressure, viscosity and velocity gradient. The relationships for the normal stresses are

$$\sigma_x = -P + 2\mu \cdot \frac{\partial V_x}{\partial x} - \frac{2\mu}{3}\left(\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}\right)$$

$$\sigma_y = -P + 2\mu \frac{\partial V_y}{\partial y} - \frac{2\mu}{3}\left(\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}\right)$$

$$\sigma_z = -P + 2\mu \frac{\partial V_z}{\partial z} - \frac{2\mu}{3}\left(\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}\right)$$

36. Which one of the following regimes of boiling curve can be considered as reverse of condensation ?

(a) Free convection boiling regime

(b) Nucleate boiling regime

(c) Transition boiling regime

(d) Film boiling regime

Ans. (d)

Sol. Boiling take heat and condensation release heat. Boiling and condensation is opposite phenomenon.

Same is explained by L. Beromley in 1950. The phenomenon of film boiling on immersed cylinders, sphere and plates is very similar to film condensation.

So, for these body, for film regime, condensation and boiling curve can be considered as reverse phenomena.

37. The service pump in a water supply system has to maintain a net static head lift of 5 m at the tank to which it delivers freely through a 4 km long pipe, wherein all minor losses can be neglected. The diameter of the pipe is 0.2m and its friction factor f = 0.01. The pumped water is discharged at 2 m/s. The absolute

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pressure differential developed by the pump is nearly (taking atmospheric pressure as 10.3 m of water)

(a) 4.5 bar (b) 5.5 bar

(c) 45 bar (d) 55 bar

Ans. **(a)**

Sol.

$$H = h + h_f$$

$$= 5 + \frac{f\ell V^2}{2gd}$$

$$= 5 + \frac{0.01 \times 4000 \times 4}{2 \times 9.81 \times 0.2}$$

$$= 45.77\text{m}$$

$$P = \rho gH$$

$$= 9810 \times 45.77$$

$$= 4.49 \text{ bar}$$

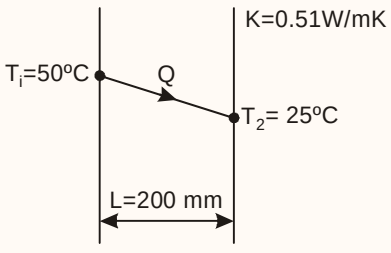
38. A wall surface of 200 mm thickness has an outside temperature of 50°C and inside temperature of 25°C with thermal conductivity of 0.51 W/m-K. the heat transfer through this wall will be

(a) 63.75 W/m^2 (b) 65.75 W/m^2

(c) 70.25 W/m^2 (d) 73.25 W/m^2

Ans. **(a)**

Sol.



Heat transfer, $q = \frac{Q}{A} = \frac{k\Delta T}{L}$

$$= \frac{0.51 \times (50 - 25)}{0.2}$$

$$= 63.75 \text{ W/m}^2$$

39. The necessary and sufficient condition for bodies in flotation to be in stable equilibrium is that the centre of gravity is located below the

(a) Metacentre

(b) Centre of buoyancy

(c) Epicenter

(d) Centroid

Ans. **(a)**

Sol.



For stable equilibrium of floating bodies, metacentre is above centre of gravity i.e. BM > BG or GM is positive.

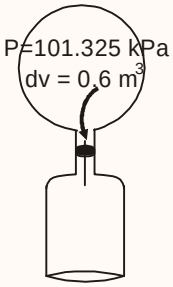
40. When the valve of an evacuated bottle is opened, the atmospheric air rushes into it. If the atmospheric pressure is 101.325 kPa and 0.6 m^3 of air enters into the bottle, then the work done by the air will be

(a) 80.8 kJ (b) 70.8 kJ

(c) 60.8 kJ (d) 50.8 kJ

Ans. **(c)**

Sol. Work done by air



$= Pdv$

$= 101.325 \times 0.6$

$= 60.8$ kJ

41. A thermodynamic cycle is composed of four processes. The heat added and the work done in each process are as follows :

Process	Heat transfer (J)	Work done (J)
1 – 2	0	50 (by the gas)
2 – 3	50 (from the gas)	0
3 – 4	0	20 (on the gas)
4 – 1	80 (to the gas)	0

The thermal efficiency of the cycle is

(a) 20.3% (b) 37.5%

(c) 40.3% (d) 62.5%

Ans. **(b)**

Sol. Thermal efficiency,

$$\eta = 1-\frac{Q_2}{Q_1} = 1-\frac{50}{80} = 37.5\%$$

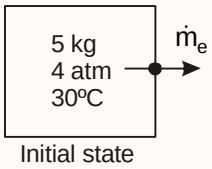
42. A steel tank placed in hot environment contains 5 kg of air at 4 atm at 30°C. A portion of the air is released till the pressure becomes 2 atm. Later, the temperature of the air in the tank is found to be 150°C. The quantity of air allowed to escape is

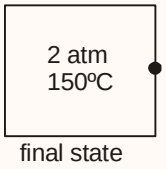
(a) 4.72 kg (b) 4.12 kg

(c) 3.71 kg (d) 3.21 kg

Ans. **(d)**

Sol.





From mass conservation,

$$\dot{m}_i - \dot{m}_e = \frac{d}{dt}m_{cv} = m_2 - m_1$$

(1) No inlet, so $\dot{m}_i = 0$

$\therefore \quad \dot{m}_e = m_1 - m_2 \qquad ...(i)$

(2) $m_1 = 5$kg (given)

$(P_1V = mRT_1)$

$$m_2 = \frac{P_2V}{RT_2} = \frac{P_2}{RT_2}\left(\frac{m_1RT_1}{P_1}\right)$$

$$= \frac{2}{423}\times\frac{5\times303}{4} = 1.79 \text{ kg}$$

From equation (i) $\dot{m}_e = 5 - 1.79 = 3.21$ kg

43. Consider the following statements :

1. Entropy is related to the first law of thermodynamics.
2. The internal energy of an ideal gas is a function of temperature and pressure.

3. The zeroth law of thermodynamics is the basis for measurement of temperature.

Which of the above statements are correct ?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (*)

44. A heat reservoir is maintained at 927 ºC. If the ambient temperature is 27ºC, the availabilty of heat from the reservoir is limited to

(a) 57% (b) 66%

(c) 75% (d) 88%

Ans. (c)

Sol. Availability of heat = $1-\frac{T_2}{T_1}=1-\frac{300}{1200}=75\%$

45. The ordinate and abscissa of the diagram to depict the isobaric processes of an ideal gas as a hyperbola are, respectively

(a) temperature and entropy

(b) internal energy and volume

(c) temperature and density

(d) enthalpy and entropy

Ans. (c)

Sol.

For an ideal gas PV = mRT

$$P = \rho RT = \text{constant}$$

$$\rho T = \text{constant}$$

i.e. equation of hyperbola

46. Consider the following statements:

1. The entropy of a pure crystalline substance at absolute zero temperature is zero.
2. the efficiency of a reversible heat engine is independent of the nature of the working substance and depends only on the temperature of the reservoirs between which it operates.
3. Carnot's theorem states that of all heat engines operating between a given constant temperature source and a given constant temperature sink, none has a higher efficiency than a reversible engine.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

47. An engine works on the basis of Carnot cycle operating between temperatures of 800 K and 400 K. If the heat supplied is 100 kW, the output is

(a) 50 kW (b) 60 kW

(c) 70 kW (d) 80 kW

Ans. (a)

Sol. Efficiency, $\eta = 1-\frac{T_2}{T_1}=\frac{\text{Work O/P}}{\text{Heat I/P}}$

$$\Rightarrow 1-\frac{400}{800}=\frac{\text{Work O/P}}{\text{Heat I/P}}$$

$\Rightarrow$ Work output = 50 kW

48. The coefficient of performance of a heat pump working on reversed Carnot cycle is 6. If this machine works as a refrigerator with work input of 10 kW, the refrigerating effect will be

(a) 35 kW (b) 40 kW

(c) 45 kW (d) 50 kW

Ans. (d)

Sol. $COP)_{refer} = COP)_p - 1 = 6 - 1 = 5$

$$COP)_{ref} = \frac{RE}{\text{work input}}$$

$$5 = \frac{RE}{10} \Rightarrow R.E = 50\,kW$$

49. Which of the following devices complies with the Clausius statement of the second law of thermodynamics?

(a) Closed-cycle gas turbine

(b) Internal combustion engine

(c) Steam power plant

(d) Domestic refrigerator

Ans. **(d)**

Sol. Clausius statement is related to refrigerator and heat pump not with heat engine.

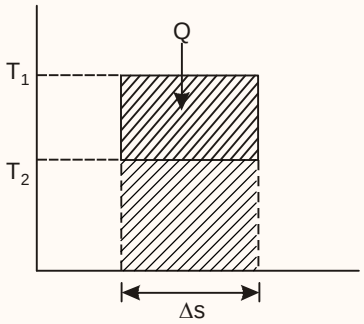
50. A reversible Carnot engine operates between 27°C and 1527°C, and produces 400 kW of net power. The change of entropy of the working fluid during the heat addition process is

(a) 0.222 kW/K (b) 0.266 kW/K

(c) 0.288 kW/K (d) 0.299 kW/K

Ans. **(b)**

Sol.



$$\text{Efficiency, } \eta = 1 - \frac{T_2}{T_1} = \frac{\text{Work O/P}}{\text{Heat I/P}}$$

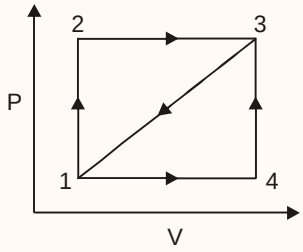
$$1 - \frac{300}{1800} = \frac{400}{Q}$$

$\Rightarrow$ Heat input = 480 kN

or $T_1 \Delta S = 480$ kW

$$\text{Entropy change, } \Delta S = \frac{480}{1800} = 0.266\,kW/K$$

51. A system absorbs 100 kJ as heat and does 60 kJ work along the path 1-2-3. The same system does 20 kJ work along the path 1-4-3. The heat absorbed during the path 1-4-3 is



(a) –140 kJ (b) –80 kJ

(c) 80 kJ (d) 60 kJ

Ans. **(d)**

Sol.

For process 1 – 2 –3

$$Q_{123} = U_3 - U_1 + W_{123}$$

$U_3 - U_1 = Q_{123} - W_{123} = 100 - 60 = 40$ kJ

For process 1 – 4 – 3

$$Q_{143} = U_3 - U_1 + W_{143}$$
$$= 40 + 20 = 60 \text{ kJ}$$

52. Two reversible engines are connected in series between a heat source and a sink. The

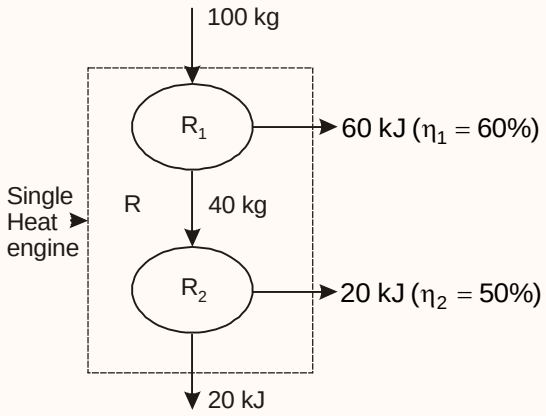
efficiencies of these engines are 60% and 50%, respecitvely. If these two engines are replaced by a single reversible engine, the efficiency of this engine will be

(a) 60% (b) 70%

(c) 80% (d) 90%

Ans. **(c)**

Sol.



Efficiency of new heat engine (R)

$$= 1-\frac{Q_2}{Q_1}=1-\frac{20}{100}$$

$$= 80\%$$

53. Consider the following statements for the air-standard efficiency of Diesel cycle:

1. For the same compression ratio, the efficiency decreases with increasing cutoff ratios.
2. For the same compression ratio and same heat input, Diesel cycle is more efficient than Otto cycle.
3. For constant maximum pressure and constant heat input, Diesel cycle is more efficient than Otto cycle.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 2 only

(c) 1 and 3 only (d) 2 and 3 only

Ans. **(c)**

Sol. For the same compression ratio and same heat input, Otto cycle is more efficient than Diesel cycle

54. In case of a thin cylindrical shell, subjected to an internal fluid pressure, the volumetric strain is equal to

(a) circumferential strain plus longitudinal strain

(b) circumferential strain plus twice the longitudinal strain

(c) twice the circumferential strain plus longitudinal strain

(d) twice the circumferential strain plus twice the longitudinal strain

Ans. **(c)**

Sol. Volumetric strain, ϵ_v = longitudinal strain (ϵ_ℓ) + 2 × circumferential strain (ϵ_θ)

55. The refractory lining of a furnace has a thickness of 200 mm. The average thermal conductivity of the refractory material is 0.04 W/m-K. The heat loss is estimated to be 180 kJ/hr/m^2. The temperature difference across the lining will be

(a) 280°C (b) 250°C

(c) 240°C (d) 220°C

Ans. **(b)**

Sol.

$$\frac{Q}{A}=\frac{k\Delta T}{L}$$

$$\frac{180\times10^3}{3600}=\frac{0.04\times\Delta T}{0.2}$$

Temperature difference (ΔT) across refractory lining = 250°C

56. In forced convection, the surface heat transfer coefficient from a heated flat plate is a function of

(a) Re and Gr (b) Pr and Gr

(c) Re and Pr (d) Re, Gr and Pr

where Re is Reynolds number, Pr is Prandtl number and Gr is Grashof number

Ans. **(c)**

57. It is desired to increase the heat dissipation rate from the surface of an electronic device of spherical shape of 5 mm radius exposed to convection with h = 10 W/m^2-K by encasing it in a spherical sheath of conductivity 0.04 W/m^2-K. For maximum heat flow, the critical diameter of the sheath shall be

(a) 20 mm (b) 18 mm

(c) 16 mm (d) 12 mm

Ans. **(c)**

Sol. For sphere, Critical radius, $r_c = \frac{2k}{h} = \frac{2\times 0.04}{10}$

= 8 mm

$\therefore$ Critical diameter, d_c = 16 mm

58. If the intake air temperature of an IC engine increases, its efficiency will

(a) remain same

(b) decrease

(c) increase

(d) remain unpredictable

Ans. **(b)**

59. In a counterflow heat exchanger, hot gases enter the system at 200ºC and leave at 80ºC. The temperature of the outside air entering the unit is 35ºC. Its temperature at the exit is 90º C. The heat exchanger has an effectiveness of

(a) 0.35 (b) 0.34

(c) 0.33 (d) 0.32

Ans. **(*)**

Sol. Counter flow heat exchanger

T_{hi} = 200°C

T_{he} = 80°C

T_{ci} = 35°C

T_{ce} = 90°C

Effectiveness of heat exchanger,

$$\in = \frac{C_{min}(T_{hi}-T_{he})}{C_{min}(T_{hi}-T_{ci})}$$

$$= \frac{200-80}{200-35} = 0.73$$

60. In one cylinder of a diesel engine receives more fuel than the others, it is a serious condition for that cylinder and can be checked by

1. judging the seizure of the piston
2. checking incomplete combustion in that cylinder
3. checking cylinder exhaust temperature with a pyrometer

Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. **(d)**

61. Consider the following statements:

1. In spur gears, the contact occurs abruptly on a line parallel to the axis, and the disengagement too is abrupt.

2. In helical gears, both loading and unloading are gradual, and therefore, these happen more smoothly and less noisily.
3. When two gears mesh, any arbitrary shape of the tooth can be chosen for the profile of the teeth of any one of the two gears, and the profile for the other shall be obtained by applying the law of gearing.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. In spur gears, the contact takes place on a line parallel to the axis abruptly and disengagement is also abrupt. In helical gears, the loading and unloading is gradual and therefore, the action is more smooth and less noisy.

It has been proved that any arbitrary shape of the tooth can be chosen for profile of teeth of one of the two gears in mesh and the profile for the other may be determined to satisfy the law of gearing. Such teeth are called conjugate teeth. Theoretically, such profile teeth will transmit the desired motion but objection to such random profiles is the obvious difficulty of manufacture, standardisation and cost of production.

62. The interference between a given pinion tooth and a gear tooth can be avoided by using

1. smaller pressure angle
2. larger pressure angle
3. less number of teeth on the gear for a pinion with predefined number of teeth
4. more number of teeth on the gear for a pinion with predefined number of teeth

Which of the above statements are correct?

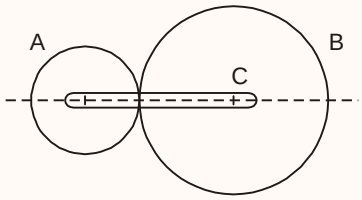
(a) 1 and 4 (b) 1 and 3
(c) 2 and 4 (d) 2 and 3

Ans. **(c)**

Sol. Use of a larger pressure angle can eliminate interference. Larger pressure angle results in smaller base circle. As a result, more of the tooth profiles become involute. In this case, the tip of the tooth of one gear will not have a chance to contact the flank of the other gear on its non-involute portion.

Increasing the number of teeth on the gear can also eliminate the chances of interference.

63. A gear train is as shown in the figure below, in which gears A and B have 20 and 40 teeth, respectively. If arm C is fixed and gear A rotates at 100 rpm, the speed of gear B will be



(a) 90 rpm (b) 75 rpm
(c) 50 rpm (d) 20 rpm

Ans. **(c)**

Sol.
$$\frac{N_B}{N_A} = \frac{T_A}{T_B}$$

$$\frac{N_B}{100} = \frac{20}{40}$$

$$N_B = 50 \text{ rpm}$$

64. A single-cylinder reciprocating engine works with a stroke of 320 mm, mass of reciprocating parts as 45 kg and mass of revolving parts as

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35 kg at crank radius. If 60% of the reciprocating parts and all the revolving parts are to be balanced, then the balancing mass required at a 300 mm radius is nearly

(a) 33.1 kg (b) 36.3 kg

(c) 39.5 kg (d) 42.7 kg

Ans. **(a)**

Sol. Length of stroke = 320 mm

Mass of reciprocating parts = 45 kg

Mass of revolving parts = 35 kg

Mass of reciprocating parts to be balanced = 0.6 × 45 = 27 kg

Therefore, mass to be balanced = 27 kg + 35kg = 62 kg

$$\text{Crank radius} = \frac{320}{2} = 160\text{mm}$$

$$m_c r_c = mr$$

$$m_c \times 300 = 62 \times 160$$

$$m_c = 33.06 \text{ kg}$$

65. Consider the following statements:

1. Gyroscopic effects generate forces and couples which act on the vehicles, and these effects must be taken into account while designing their bearings.
2. Rolling motion of a ship usually occurs because of the difference in buoyancy on the two sides of the ship due to a wave.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(c)**

Sol. Rolling motion usually occurs because of the difference in buoyancy on the two sides of a ship due to a wave. This is a periodic couple and has a maximum value when the ship is on either side of the wave at the point of maximum slope and zero when the ship is at a peak or in the trough of the wave.

The gyroscopic effects generates forces and couples which act on the vehicles and other means of transport like ships, aeroplanes etc. These effects must be taken into account while designing them especially in selection of bearings etc.

66. When two shafts, one of which is hollow, are of the same length and transmit equal torques with equal maximum stress, then they should have equal

(a) polar moments of inertia

(b) polar moduli

(c) diameters

(d) angles of twist

Ans. **(b)**

67. A solid rod of circular cross-section mad of brittle material, when subjected to torsion, fails along a plane at 45° to the axis of the rod. Consider the following statements as pertaining thereto:

1. Distortion energy is maximum on this 45° plane
2. Shear stress is maximum on this 45° plane
3. Normal stress is maximum on this 45° plane

Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. **(c)**

68. A riveted joint may fail by

1. tearing of the plate at an edge
2. tearing of the plate across a row of rivets
3. shearing of rivets

Which of the above are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

69. An offset provided in radial cam-translating-follower mechanism serves to

(a) decrease the pressure angle during ascent of the follower

(b) increase the pressure angle during ascent of the follower

(c) avoid possible obstruction due to some machine parts

(d) decrease the pressure angle during descent of the follower

Ans. (a)

70. In combined parallel and transverse fillet welded joint

(a) the parallel portion will fail due to tension, whereas the transverse portion will fail due to shear

(b) the transverse portion will fail due to tension, whereas the parallel portion will failure to shear

(c) both parallel and transverse portions will fail due to tension

(d) both parallel and transverse portions will fail due to shear

Ans. (b)

Sol. The transverse portion fails under tension due to normal stress and parallel portion will fail due to shear.

71. In a journal bearing, the diameter of the journal is 0.15 m, its speed is 900 rpm and the load on the bearing is 40 kN. Considering $\mu = 0.0072$, the heat generated will be nearly

(a) 1 kW (b) 2 kW

(c) 3 kW (d) 4 kW

Ans. (b)

Sol. Heat generated

$$= \mu W r \omega$$

$$= 0.0072 \times 40 \times \frac{0.15}{2} \times \frac{2\pi \times 900}{60}$$

$$= 2.035 \text{ kW}$$

72. Which one of the following governors is having a larger displacement of sleeve for a given fractional change of speed?

(a) Stable governor

(b) Sensitive governor

(c) isochronous governor

(d) Hunting governor

Ans. (b)

73. Consider the following statements:

1. HSS tools wear very rapidly, whereas in cemented carbide tools, even though hardness is retained, crater wear can occur due to solid-state diffusion.
2. Cutting tools made of Super-HSS, also known as cobalt-based HSS, are made by adding 2% to 15% of cobalt which increases the cutting efficiency at heavier cuts by increasing the hot hardness and wear resistance.
3. Tools failure due to excessive stress can be minimized by providing small or negative rake angles on brittle tool

materials, protecting tool tip by providing large side-cutting edge angles, and honing a narrow chamfer along the cutting edge.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

Sol. When HSS tool is used at higher cutting temperature, then due to plastic deformation and crater wear, it wears very rapidly. At high temperature the hot hardness of HSS tool is low which leads to plastic deformation.

Crater wear occurs at some distance away from tool tip on tool face. It is mainly due to high temperature where solid state diffusion can cause rapid wear.

This type of wear is important in case of carbide tool materials when they are used at higher temperature, where they can retain their hot hardness but wear out due to crater wear.

74. The resilience of steel can be found by integrating stress-strain curve up to the

(a) ultimate fracture point

(b) upper yield point

(c) lower yield point

(d) elastic point

Ans. (d)

Sol. Risilience is the ability of a material to absorb energy per unit volume without permanent deformation and is equal to the area under the stress-strain curve up to the elastic limit.

75. While turning a 60 mm diameter bar, it was observed that the tangential cutting force was 3000 N and the feed force was 1200 N. If the tool rake angle is 32°, then the coefficient of friction is nearly (may take sin 32° = 0.53, cos 32° = 0.85 and tan 32° = 0.62)

(a) 1.37 (b) 1.46

(c) 1.57 (d) 1.68

Ans. (a)

Sol. F_c = 3000 N

F_1 = 1200 N

α = 32°, sin 32° = 0.53, cos 32° = 0.85, tan 32° = 0.62

$$\mu = \tan\beta = \frac{F}{N} = \frac{F_c \sin\alpha + F_t \cos\alpha}{F_c \cos\alpha - F_t \sin\alpha}$$

$$= \frac{3000 \times 0.53 + 1200 \times 0.85}{3000 \times 0.85 - 1200 \times 0.53} = \frac{2610}{1914}$$

μ = 1.3636

76. For spot welding of 1 mm thick sheet with a current flow time of 0.2 s, the heat generated is 1000 J. If the effective resistance is 1200 μΩ, the current required is

(a) 4000 A (b) 5000 A

(c) 6000 A (d) 7000 A

Ans. (b)

Sol.

$$\mu = I^2Rt$$

$$1000 = I^2 \times 200 \times 10^{-6} \times 0.2$$

$$I = 5000 \text{ A}$$

77. The maximum possible draft in rolling, which is the difference between initial and final thicknesses of the sheet metal, depends on

(a) rolling force

(b) roll radius

(c) roll width

(d) yield shear stress of the material

Ans. **(b)**

Sol. $(\Delta h)_{max} = \mu^2 R$

It is clear that large roll radius and high friction allows heavy draft. Thus as roll radius increases maximum possible draft increases.

78. For a strain gauge (gauge factor = 2.1 and resistance = 50Ω), subjected to a maximum strain of 0.001, the maximum change in resistance is

(a) 0.084 Ω (b) 0.105 Ω

(c) 0.135 Ω (d) 0.156 Ω

Ans. **(b)**

Sol.

$$\text{Gauge factor} = \frac{\text{change in resistance/resistance}}{\text{change in length / length}}$$

$$= \frac{\Delta R / R}{\Delta L / L}$$

$$2.1 = \frac{\Delta R}{0.001 \times 50}$$

$$\Rightarrow \quad \Delta R = 0.105$$

79. Consider the following statements:

Dispatching authorizes the start of production operation by

1. releasing of material and components from stores to the first process
2. releasing of material from process to process
3. issuing of drawing and instruction sheets

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

80. Which one of the following forecasting models best predicts the turning point?

(a) Simple exponential smoothing model

(b) Brown's quadratic smoothing model

(c) Double exponential smoothing model

(d) Moving average model (using 5 data points)

Ans. **(d)**

81. The material removal rate will be higher in ultrasonic machining process for materials with

(a) higher ductility

(b) higher fracture strain

(c) higher toughness

(d) lower toughness

Ans. **(d)**

Sol. Ultrasonic machining process uses vibrational energy of vibrating tool which hammers on workpiece and due to mechanical impact of abrasive, workpiece factures. Thus material removal rate will be higher for those material which are brittle in nature or lower in toughness.

82. In queuing theory with multiple servers, the nature of the waiting situation can be studied and analysed mathematically, if

(a) the complete details of the items in the waiting lines are known

(b) the arrival and waiting times are known and can be grouped to form an appropriate waiting line model

(c) all the variables and constants are known and they may form a linear equation

(d) the laws governing arrivals, service times and the order in which the arriving units are taken into service are all known

Ans. (d)

83. In any crash program for a project

(a) both direct and indirect costs increase

(b) indirect costs increase and direct costs decrease

(c) direct costs increase and indirect costs decrease

(d) cost are no criterion

Ans. (c)

84. Tools signature is

(a) a numerical method of identification of the tools

(b) the plan of the tool

(c) the complete specification of the tool

(d) associated with the tool manufacturer

Ans. (a)

Sol. Tool signature according to ASA is the numerical method of identification of tool according to which seven elements comprising signatgure of single edge tools are always stated in the following orders.

Back rake angle- side rake angle- End relief angle - side relief angle - end cutting edge angle - side cutting edge angle - tool nose radius.

85. With reference to a microprocessor, RISC stands for

(a) Redefined Instruction Set Computer

(b) Reduced Instruction Set Computer

(c) Restructured Instruction Set Computer

(d) Regional Instruction Set Computer

Ans. (b)

Sol. RISC stands for reduced instruction set computer.

86. An Or logic control in pneumatic systems is possible with the help of

(a) sequence valve

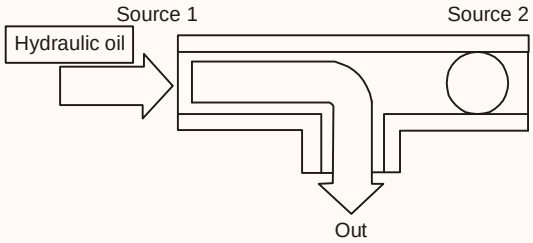
(b) shuttle value

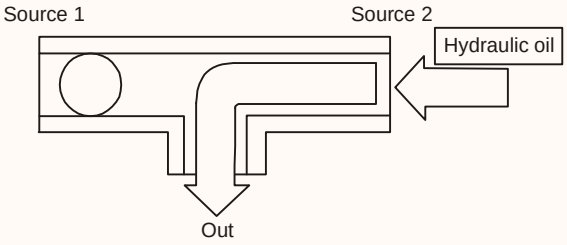
(c) dual pressure valve

(d) delay valve

Ans. (b)

Sol.





The shuttle valve is a type of valve which allows fluid to flow through it from one of two sources.

So it can function as an OR logic control in pneumatic systems.

SCROLL DOWN

87. Which one of the following is ***not*** an Addressing Mode in 8085?

(a) Immediate (b) Indirect

(c) Register (d) Segment

Ans. **(d)**

Sol. There are 5 addressing modes of 8085

(1) Immediate addressing

(2) Register addressing

(3) Direct addressing

(4) Indirect addressing

(5) Implied Addressing

88. Consider the following statements regarding Programming Logic Controller (PLC):

1. It was developed to replace the microprocessor.
2. Wiring between device and relay contracts are done in its program.
3. Its I/O interface section connects it to external field devices.
4. It requires extensive wiring in the application.

(a) 1 and 3 (b) 1 and 4

(c) 2 and 3 (d) 2 and 4

Ans. **(c)**

89. If B is the magnetic flux density at right angles to a plate, I is the current flow through the plate, t is the plate thickness and K_H is Hall coefficient, the resultant transverse potential difference V for Hall sensor is given by

(a) $K_H \frac{Bt}{I}$ (b) $K_H \frac{t}{BI}$

(c) $K_H \frac{BI}{t}$ (d) $K_H \frac{I}{Bt}$

Ans. **(c)**

Sol. Hall effect voltage is given by:

$$V_H = K_H \times \left(\frac{I}{t} \times B\right)$$

90. The specific speed of a hydraulic turbine depends on

(a) speed and power developed

(b) speed and water head

(c) discharge and power developed

(d) speed, head and power developed

Ans. **(d)**

91. Consider the following statements with reference to combustion and performance in a four-stroke petrol engine :

1. The auto-ignition temperature of petrol as a fuel is higher than that of diesel oil as a fuel.
2. The highest compression ratio of petrol engines is constrained by the possibility of detonation.
3. A petrol engine is basically less suitable for supercharging than a diesel engine.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

92. In a flooded evaporator refrigerator, an accumulator at the suction side of the compressor is provided to

(a) collect the vapours

(b) detect any liquids in the vapour

(c) retain the refrigeration effect as originally working

(d) collect the liquid refrigerant and preclude its reversion to the compressor

Ans. (d)

93. A four-stroke single-cylinder SI engine of 6 cm diameter and 10 cm stroke running at 4000 rpm develops power at a mean effective pressure of 10 bar. The power developed by the engine is

(a) 9.42 kW (b) 5.54 kW

(c) 4.92 kW (d) 2.94 kW

Ans. (a)

Sol. $\text{Power} = V_s \times P_{mep}$

$$= A \times L \times \frac{N}{60} \times \frac{1}{2} \times K \times P_{mep}$$

$$= \frac{\pi}{4} \times 0.06^2 \times 0.1 \times \frac{4000}{60} \times \frac{1}{2} \times 10 \times 10^5$$

$$= 9.424 \text{ kW}$$

94. Which of the following actions will help to reduce the black smoke emission of a diesel engine?

1. Run at lower load, i.e., derating
2. Have regular maintenance of the diesel engine, particularly of injection system
3. Use diesel oil of higher cetane number

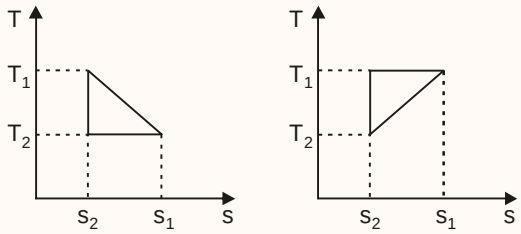
Select the correct answer using the code given below.

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

95. What is the ratio of the efficiencies $\left(\frac{\eta_I}{\eta_{II}}\right)$ for the two cycles as shown in the T-s diagrams?



(a) $\frac{T_1 + T_2}{2T_1}$ (b) $\frac{T_1 + T_2}{2T_2}$

(c) $\frac{2T_2}{T_1 + T_2}$ (d) $\frac{2T_1}{T_1 + T_2}$

Ans. (d)

Sol. Work is same in both cycle

$$\eta_I = \frac{W}{\frac{1}{2}(T_1 + T_2)\Delta S} \text{ and } \eta_{II} = \frac{W}{T_1 \Delta S}$$

$$\therefore \frac{\eta_I}{\eta_{II}} = \frac{T_1 \Delta S}{\frac{1}{2}(T_1 + T_2)\Delta S} = \frac{2T_1}{T_1 + T_2}$$

96. A four-stroke engine having a brake power of 105 kW is supplied with fuel at the rate of 4.4 kg/min for 10 minutes. The brake specific fuel consumption of the engine is

(a) 0.18 kg/kW-hr (b) 0.25 kg/kW-hr

(c) 0.36 kg/kW-hr (d) 0.42 kg/kW-hr

Ans. (b)

97. Consider the following statements :

1. Recycling exhaust gases by partial mixing with the intake gases increases the emission of oxides of nitrogen from the engine.

SCROLL DOWN

2. The effect of increase in altitude of operation on the carburetor is to enrich the entire port-throttle operation.
3. When the carburetor throttle is suddenly opened, the air-fuel mixture may lean out temporarily resulting in engine stall.
4. Use of multi-venturi system makes it possible to obtain a high velocity airstream when the fuel is introduced at the main venturi throat.

Which of the above statements are correct?

(a) 1 and 3 (b) 1 and 4
(c) 2 and 3 (d) 2 and 4

Ans. (c)

98. In IC engine

1. the ideal air capacity of a two-stroke engine is the mass of air required to concurrently fill the total cylinder volume at inlet temperature and exhaust pressure
2. with increase in air-fuel ratio beyond the value for maximum power, there is a fall in power developed and this fall is more with higher values of air-fuel ratio.
3. the volumetric efficiency of the engine depends on the design of intake and exhaust manifold.

Which of the above are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

99. Consider the following statements :

1. Heat pumps and air conditioners have the same mechanical components.
2. The same system can be used as heat pump in winter and as air conditioner in summer.
3. The capacity and efficiency of a heat pump fall significantly at high temperatures.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

100. The following are the results of a Morse test conducted on a four-cylinder, four-stroke petrol engine at a common constant speed in all cases :

The brake power of the engine when all the cylinders are firing is 80 kW. The brake power of the engine when each cylinder is cut off in turn is 55 kW, 55.5 kW, 54.5 kW and 55 kW, respectively

The mechanical efficiency of the engine when all the cylinders are firing will be

(a) 90% (b) 85%
(c) 80% (d) 75%

Ans. (c)

Sol.

$$BP = 80 \text{ kW}$$

$$BP_1 = 55 \text{ kW} = BP - IP_1$$

$$IP_1 = BP - BP_1$$
$$= 25 \text{ kW}$$

$$IP_2 = BP - BP_2$$
$$= 24.5 \text{ kW}$$

$$IP_3 = BP - BP_3$$
$$= 25.5 \text{ kW}$$

$$IP_4 = BP - BP_4$$
$$= 25 \text{ kW}$$

Total $IP = IP_1 + IP_2 + IP_3 + IP_4 = 100$ kW

$$\eta_{me} = \frac{BP}{IP} = \frac{80}{100} = 0.8 = 80\%$$

101. An ideal refrigerator working on a reversed Rankine cycle has a capacity of 3 tons. The COP of the unit is found to be 6. The capacity of the motor required to run the unit is (take 1 T = 210 kJ/min)

(a) 1.85 kW (b) 1.75 kW

(c) 1.65 kW (d) 1.50 kW

Ans. **(b)**

Sol.

$$Q_L = 3 \times 3.5 = 10.5 \text{ kW}$$

$$COP = 6$$

$$= \frac{Q_L}{W}$$

$$W = \frac{10.5}{6} = 1.75 \text{kW}$$

102. A flywheel weighs $\frac{981}{\pi}$ kgf and has a radius of gyration of 100 cm. It is given a spin of 100 r.p.m. about its horizontal axis. The whole assembly is rotating about a vertical axis at 6 rad/s. The gyroscopic couple experienced will be

(a) 2000 kgf-m (b) 1962 kgf-m

(c) 200 kgf-m (d) 196 kgf-m

Ans. **(a)**

Sol. Gyroscopic couple = $I\omega\omega_p$

$$= \frac{981}{\pi} \times 1^2 \times \frac{2\pi \times 100}{60} \times 6$$

$$= 19620 \text{ Nm}$$

$$= 2000 \text{ kgf-m}$$

103. A cold storage has capacity for food preservation at a temperature of –3 °C when the outside temperature is 27 °C. The minimum power required to operate with a cooling load of 90 kW is

(a) 20 kW (b) 15 kW

(c) 10 kW (d) 5 kW

Ans. **(c)**

Sol.

$$COP = \frac{T_L}{T_H - T_L} = \frac{270}{300 - 270} = \frac{270}{30} = 9$$

$$COP = 9 = \frac{Q_L}{W}$$

$$9 = \frac{90}{W}$$

$$W = 10 \text{ kW}$$

104. In a vapour absorption refrigerator, the temperature of evaporator and ambient air are 10 °C and 30 °C, respectively. For obtaining COP of 2 for this system, the temperature of the generator is to be nearly

(a) 90 °C (b) 85 °C

(c) 80 °C (d) 75 °C

Ans. **(c)**

Sol.

$$COP = \frac{T_e(T_G - T_0)}{T_G(T_0 - T_e)}$$

$$2 = \frac{283(T_G - 303)}{T_G(303 - 283)}$$

$T_G = 352.87\ K$

$= 79.87°C \approx 80°C$

105. The following data refer to a vapor compression refrigerator :

Enthalpy at compressor inlet = 1200 kJ/kg

Enthalpy at compressor Outlet = 1400 kJ/kg

Enthalpy at condenser Outlet = 200 kJ/kg

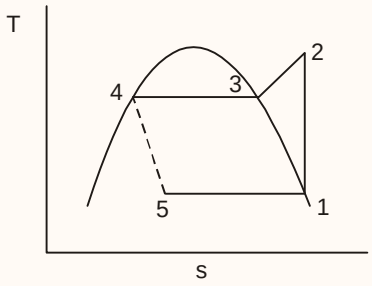
The COP of the refrigerator is

(a) 7 (b) 6

(c) 5 (d) 4

Ans. (c)

Sol.



$h_1 = 1200\ kJ/kg$

$h_2 = 1400\ kJ/kg$

$h_4 = 200\ kJ/kg$

$$COP = \frac{Q_L}{W}$$

$$= \frac{h_1 - h_5}{h_2 - h_1} = \frac{1200 - 200}{1400 - 1200}$$

$$= \frac{1000}{200} = 5$$

106. The compressor of an ammonia refrigerating machine has a volumetric efficiency of 85% and swept volume of 0.28 m^3/min. Ammonia having a dry specific volume of 0.25 m^3/kg enters the compressor with a dryness fraction of 0.7. The mass flow rate of ammonia through the machine is

(a) 1.28 kg/min (b) 1.36 kg/min

(c) 1.42 kg/min (d) 1.57 kg/min

Ans. (b)

Sol.

$\eta_{vol} = 85\%$

$V_s = 0.28 m^3/min$

$V_g = 0.25 m^3/kg$

$x = 0.7$

$v_1 = v_f + x(v_g - v_f) \approx x\, v_g$

$$\eta_{vol} = \frac{\dot{m} v_1}{V_{swept}}$$

$0.28 \times 0.85 = \dot{m} v_1$

$\dot{m} v_1 = 0.28 \times 0.85$

$\dot{m} \times x v_g = 0.28 \times 0.85$

$\dot{m} = 0.7 \times 0.25 = 0.28 \times 0.85$

$\dot{m} = 1.36\ kg/min$

107. Air is drawn in a compressor at the rate of 0.8 kg/s at a pressure of 1 bar and temperature of 20 °C, and is delivered at a pressure of 10 bar and temperature of 90 °C. This air delivery is through an exit valve of area 2×10^{-3} m^2. If R is 287 kJ/kg-K, the exit velocity of the air is

(a) 41.7 m/s (b) 35.8 m/s
(c) 29.7 m/s (d) 27.3 m/s

Ans. (a)

Sol.

$$\dot{m} = (\rho AV)_{exit}$$

$$0.8 = \left(\frac{P}{RT} \times A \times V\right)_{exit}$$

$$0.8 = \frac{10 \times 10^2}{0.287 \times 363} \times 2 \times 10^{-3} \times V_{exit}$$

$$V_{exit} = 41.7 \text{ m/s}$$

108. Consider the following statements :

1. The operation of a refrigerator unit at more than one temperature can be accomplished by using different throttling valves and a separate compressor for each 'temperature range'.
2. The refrigerated space must be maintained above the ice point to prevent freezing.
3. In domestic refrigerators, the refrigerant is throttled to a higher pressure in the freezer followed by full expansion in the refrigerated space.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

109. Which one of the following methods is more effective to improve the efficiency of the Rankine cycle used in thermal power plant?

(a) Increasing the condenser temperature
(b) Decreasing the condenser temperature
(c) Decreasing the boiler temperature
(d) Increasing the boiler temperature

Ans. (b)

110. Consider the following statements regarding vapour absorption systems in the field of refrigeration :

1. In ammonia-water absorption system, ammonia is the refrigerant.
2. In water-lithium bromide system, water is the refrigerant.
3. Ammonia-water absorption reaction is endothermic.
4. The amount of ammonia absorbed by water is inversely proportional to the temperature of ammonia.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 1, 2 and 4 (d) 2, 3 and 4

Ans. (c)

111. In an air-handling unit, air enters the cooling coil at a temperature of 30 °C. The surface temperature of the coil is –10 °C. If the bypass factor of the coil is 0.45, then the temperature of the air at the exit will be

(a) 6 °C (b) 8 °C
(c) 10 °C (d) 12 °C

Ans. (b)

Sol.

$$BPF = \frac{T_{exit} - T_{coil}}{T_{entry} - T_{coil}}$$

$$0.45 = \frac{T_{exit} + 10}{30 + 10}$$

$$T_{exit} = 8°C$$

112. Consider the following statements :

1. The relative humidity of air does not change with temperature as long as specific humidity remains constant.

2. Dew-point temperature is the temperature at which air is cooled at constant volume
3. Saturated air passing over a water surface does not cause change of air temperature
4. For saturated air, dry bulb, wet-bulb and dew point temperatures are identical

Which of the above statements are correct?

(a) 1 and 2 (b) 2 and 3

(c) 1 and 4 (d) 3 and 4

Ans. (d)

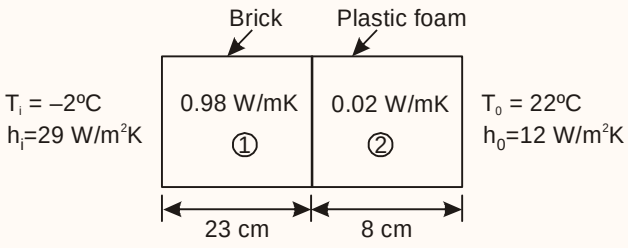
113. A cold storage has 23 cm brick wall on the outsdie and 8 cm plastic foam on the inside. The inside and outside temperatures are –2°C and 22°C, respectively. If the thermal conductivities of brick and foam are 0.98 W/m-K and 0.02 W/m-K, and the inside and outside heat transfer coefficients are 29 W/m^2-K and 12 W/m^2-K, respectively, then the rate of heat removal for a (projected) wall area of 90 m^2 will nearly be

(a) 503 W (b) 497 W

(c) 490 W (d) 481 W

Ans. (b)

Sol.



$$\text{Heat removal rate, } Q = \frac{A\Delta T}{\frac{1}{h_i} + \frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{1}{h_0}}$$

$$= \frac{90 \times [22 - (-2)]}{\frac{1}{29} + \frac{0.23}{0.98} + \frac{0.08}{0.02} + \frac{1}{12}}$$

= 497 W

114. Consider the following statements :

1. The distinguishing features of a radial flow reaction turbine are – (i) only a part of the total head of water is converted into velocity head before it reaches the runner and (ii) the flow through water completely fills all the passages in the runner.
2. Kaplan turbine is essentially a propeller working in reverse, and its blades are so mounted that all the blade angles can be adjusted simultaneously by means of suitable gearing even as the machine is in operation
3. A draft tube is pipe of gradually increasing cross-sectional area which must be airtight, and under all conditions of operation, its lower end must be submerged below the level of the discharged water in the tailrace.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

115. The specific speed of a turbine is the speed of an imaginary turbine, identical with the given turbine, which

(a) delivers unit discharge under unit speed

(b) delivers unit discharge under unit head

(c) develops unit discharge under unit speed

(d) develops unit power under unit head

Ans. (d)

116. The mechanical efficiency of a centrifugal pump is the ratio of

(a) manometeric head to the energy supplied by the impeller per kN of water

(b) energy supplied to the pump to the energy available at the impeller

(c) actual work done by the pump to the energy supplied to the pump by the prime mover

(d) energy available at the impeller to the energy supplied to the pump by the prime mover

Ans. (d)

117. Consider the following advantages of rotay pumps compared to reciprocating pumps :

1. Steady discharge which increases with decrease in head
2. Suitable for handling fluids with suspended solid particles
3. Less bulky than positive displacement pumps
4. Can be started with open delivery with least load

Which of the above advantages are correct?

(a) 1 ,2 and 3 (b) 1, 2 and 4

(c) 1, 3 and 4 (d) 2, 3 and 4

Ans. (c)

118. According to aerofoil theory, the guide angle of Kaplan turbine blades is defined as the angle between

(a) Lift and resultant force

(b) drag and resultant force

(c) lift and tangential force

(d) lift and drag

Ans. (a)

119. An ideal closed-cycle gas turbine plant is working between the temperatures 927°C and 27°C using air as working fluid. The pressure ratio for maximum output is

(a) 11.3 (b) 13.3

(c) 15.3 (d) 17.3

Ans. (a)

Sol. For maximum output, pressure ratio,

$$r_p = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{1200}{300}\right)^{\frac{1.4}{2(1.4-1)}} = 11.3$$

120. The critical speed of a turbine is

(a) same as the runaway speed

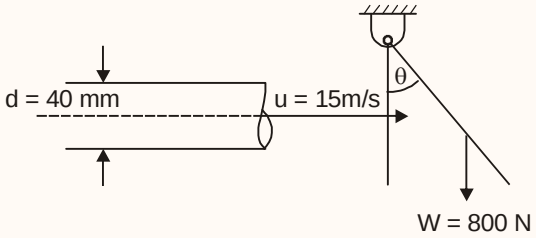
(b) the speed that will lead to mechanical failure of the shaft

(c) the speed which equals the natural frequency of the rotor

(d) the speed equal to the synchronous speed of the generator

Ans. (c)

121. A 40 mm diameter water jet strikes a hinged vertical plate of 800 N weight normally at its surface at its centre of gravity as shown in the figure below :



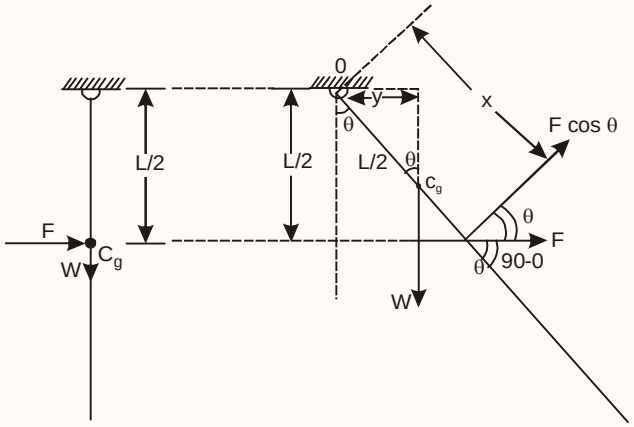
The angle of deflection is nearly

(a) $\sin^{-1}$ 0.353 (b) $\sin^{-1}$ 0.321

(c) $\tan^{-1}$ 0.353 (d) $\tan^{-1}$ 0.321

Ans. (a)

Sol.



Taking moment about O at equilibrium position

$$F\cos\theta \times x = W \times y$$

$$F\cos\theta \times \frac{L/2}{\cos\theta} = W \times \frac{L}{2}\sin\theta$$

$$F = W\sin\theta$$

$$\rho AV^2 = W\sin\theta$$

$$10^3 \times \frac{\pi}{4} \times (0.04)^2 \times 15^2 = 800\sin\theta$$

$$\sin\theta = 0.353$$

$$\theta = \sin^{-1}(0.353)$$

122. Consider the following statements regarding a Ram Jet :

1. The engine has neither a compressor nor a turbine
2. It operates at much higher temperature than a gas turbine
3. It cannot operate statically. It needs to be put in flight by some means at sufficiently high speed before it produces any thrust and propels itself.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1 , 2 and 3

Ans. (d)

123. Air centers a turbojet engine at the rate of 40 kg/s with a velocity of 250 m/s relative to an aircraft which is moving at 300 km/hr. Exhaust of the engine has a velocity of 700 m/s relative to the moving aircraft. The thrust developed by the engine is

(a) 24 kN (b) 18 kN

(c) 12 kN (d) 9 kN

Ans. (b)

Sol. Thrust $= \dot{m}(V_j - V_i)$

$= 40\ (700 - 250)$

$= 18$ kN

124. The clearnace volume in reciprocating air compressor is provided

(a) to reduce the work done per kg of air delivered

(b) to increase the volumetric efficiency of the compressor

(c) to accomodate the valves in the head of the compressor

(d) to create turbulence in the air to be delivered

Ans. (c)

125. Consider the following statemetns regarding Reheat Rankine Steam Cycle :

1. The amin purpose of reheat in Rankine cycle is to increase the efficiency of the cycle

2. In practice, the reheat is generally limited to one point of expansion
3. Due to reheat, the steam rate (specific steam consumption) is reduced.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

126. In solar flat plate collectors, the absorber plate is painted wiht selective paints. The selective is the ratio of

(a) Solar radiation-absorption to thermal infrared radiation emission
(b) Solar radiation emission to thermal infrared radiation absorption
(c) Solar radiation reflection to thermal infrared radiation absorption
(d) Solar radiation absorption to thermal infrared radiation reflection

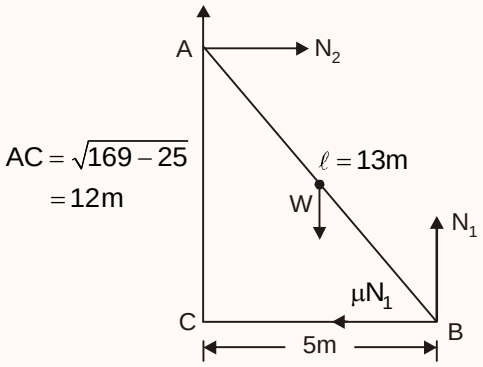
Ans. (a)

127. A 13 m long ladder is placed against a smooth vertical wall with its lower end 5 m from the wall. What should be the coefficient of friction between the ladder and the floor so that the ladder remains in equilibrium?

(a) 0.29 (b) 0.25
(c) 0.21 (d) 0.11

Ans. (c)

Sol.



Using equilibrium equation,

$$N_2 = \mu N_1$$

$$N_1 = W \qquad [\because \mu_2 N_2 = 0]$$

Taking Moment about A.

$$W \times 2.5 + \mu_1 N_1 \times 12 = N_1 \times 5$$

$$\mu = 0.2083$$

$$= 0.21$$

128. A cube strikes a stationary ball exerting an average force of 50 N over at time of 10 ms. The ball has mass of 0.20 kg. Its speed after the impact will be

(a) 3.5 m/s (b) 2.5 m/s
(c) 1.5 m/s (d) 0.5 m/s

Ans. (b)

129. Consider the followng statements regarding solid solution of metals :

1. The solubility of metallic solids is prmarily limited by size factor.
2. A metal with high ervalence can dissolve large amount of metal of lower valence.
3. A metal with same lattice crystal structure can form a sereis of solid solutions

4. The limit of solid solubility is indicated by a phase boundary called liquidus

Which of the above statements are correct?

(a) 1 and 4 (b) 2 and 4

(c) 1 and 3 (d) 1 and 2

Ans. **(c)**

Sol.

- The solubility of metallic solid is limited by relative size factor i.e. difference between the atomic radius of atoms must not be greater than 15%.
- A metal with lower valence can dissolve large amount of metal having higher valence.
- When crystal structure of solute and solvent is same then it can form a series of solid solution or it results into extensive solubility.
- The limit of solid solubility is indicated by a phase boundary called solvus.

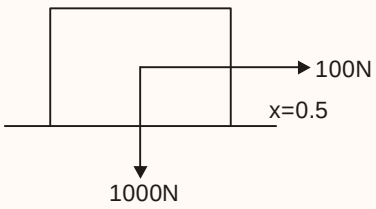
130. A box weight 1000 N is placed on the ground. The coefficient of friction between the box and the ground is 0.5. When the box is pulled by a 100 N horizontal force, the frictional force developed between the box and the ground at impending motion is

(a) 50 N (b) 75 N

(c) 100 N (d) 500

Ans. **(c)**

Sol.



Limiting frictional force = N

$\Rightarrow$ $0.5 \times 1000 = 500$ N

Frictional force = 100 N

131. A state of plane stress consists of a uniaxial tensile stress of magnitude 8 kPa, exerted on vertical surface and of unknown shearing stresses. If the largest stress is 10 kPa, then the magnitude of the unknown shear stress will be

(a) 6.47 kPa (b) 5.47 kPa

(c) 4.47 kPa (d) 3.47 kPa

Ans. **(c)**

Sol.

$$\sigma_1 = \left(\frac{\sigma_x + \sigma_y}{2}\right) \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

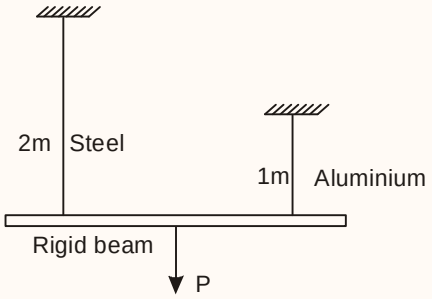
$$10 = \left(\frac{8+0}{2}\right) \pm \sqrt{\left(\frac{8-0}{2}\right)^2 + \tau_{xy}^2}$$

$$10 = 4 + \sqrt{16 + \tau_{xy}^2}$$

$$36 = 16 + \tau_{xy}^2$$

$$\Rightarrow \quad \tau_{xy} = 4.47 \text{ kPa}$$

132. A rigid beam of negligible weight is supported in a horizontal position by two rods of steel and aluminium, 2 m and 1 m long, having values of cross sectional areas 100 mm^2 and 200 mm^2, and young's modulus of 200 GPa and 100 GPa, respectively. A load P is applied as shown in the figure below:



If the rigid beam is to remain horizontal then

(a) the froce P must be applied at the centre of the beam

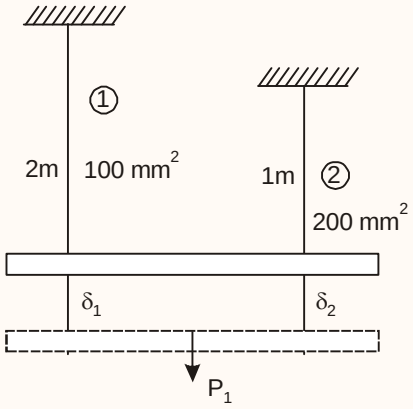
(b) the force on the steel rod should be twice the force on the aluminium rod

(c) the force on the aluminium rod should be twice the force on the steel rod

(d) the forces on both the rods should be equal

Ans. **(c)**

Sol. For rigid beam to remain horizontal



$$\delta_1 = \delta_2$$

$$\frac{P_1\ell_1}{A_1E_1} = \frac{P_2\ell_2}{A_2E_2}$$

$$\frac{P_1 \times 2}{100 \times 200} = \frac{P_2 \times 1}{200 \times 100}$$

$$P_2 = 2P_1$$

133. A soild shaft is subjected to bending moment of 3.46 kN-m and a torsional moment of 11.5 kN-m. For this case, the equivalent bending moment and twisting moment are

(a) 7.73 kN-m and 12.0 kN-m

(b) 14.96 kN-m and 12.0 kN-m

(c) 7.73 kN-m and 8.04 kN-m

(d) 14.96 kN-m and 8.04 kN-m

Ans. **(a)**

Sol. Equivalent bending moment, $M_e = \frac{1}{2}\left(M + \sqrt{M^2 + T^2}\right)$

$$= \frac{1}{2}\left(3.46 + \sqrt{3.46^2 + 11.5^2}\right)$$

$$= 7.73 \text{ kNm}$$

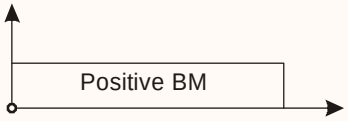
Equivalent twisting moment, $T_e = \sqrt{M^2 + T^2}$

$$= \sqrt{3.46^2 + 11.5^2}$$

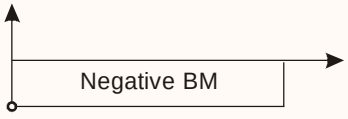
$$= 12 \text{ kNm}$$

134. Which one of the following is the correct bending moment diagram for a beam which is hinged at the ends and is subjected to a clockwise couple acting at the mid-span?

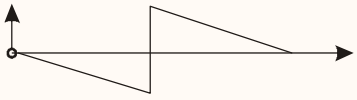
(a)



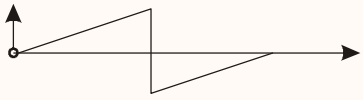
(b)



(c)

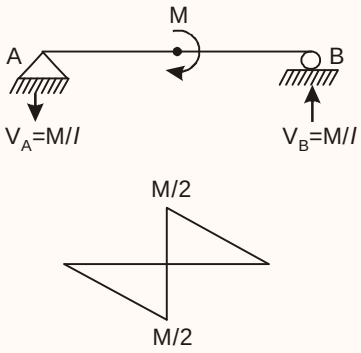


SCROLL DOWN

(d) 

Ans. **(c)**

Sol.



$$R_A + R_B = 0$$

$$\Sigma M_A = 0$$

$$V_B \times \ell = M$$

$$V_B = \frac{M}{\ell}$$

135. A steel specimen is heated to 780 °C and is then cooled at the slowest possible rate in the furnace. The property imparted to the specimen by this process is

(a) toughness

(b) hardness

(c) softness

(d) tempering

Ans. **(c)**

Sol. Toughness depends on grain size and impurity concentration. As grain size decreases its strength increases according to Hall-Petch equation. This is one of the few instances in which strength and toughness can be increased at the same time.

But when material is cooled very slowly its grain size increases thus its toughness decreases and ductility increases hence softness also increases.

136. Consider the following statements:

1. In case of a thin spherical shell of diameter d and thickness t, subjected to internal pressure p, the principal stresses at any point equal $\frac{pd}{4t}$
2. In case of thin cylinders the hoop stress is determined assuming it to be uniform across the thickness of the cylinder
3. In thick cylinders, the hoop stress is not uniform across the thickness but it varies from a maximum value at the inner circumference to a minimum value at the outer circumference.

Which of the above statements are correct?

(a) 1 and 2 only

(b) 1 and 3 only

(c) 2 and 3 only

(d) 1, 2 and 3

Ans. **(d)**

137. Addition of magnesium to cast iron increases its

(a) hardness

(b) corrosion resistance

(c) creep strength

(d) ductility and strength in tension

Ans. **(d)**

Sol. By addition of magnesium in cast iron, the

shape of graphite flakes can be modified into nodules (spheres), which increases its ductility, strength and fluidity.

138. Consider the following statements:

1. The quenching of steel results in an increase in wear resistance, strength and hardness.
2. By the process of case hardening, hard wearing resistant surface is produced on mild steel. This is an effective method for low carbon steels because they can not be hardened by the process of quenching.
3. When a metal is mixed with small atoms of non metallic element in such a manner that invading atoms occupy interstitial positions in the metal lattice, and interstitial alloy results.

What of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol.
- Quenching of steel causes increase in hardness, wear resistance and strength.
- Case hardening is an effective method for low C-steel because they have not enough carbon to be hardened by quenching, whereas by case hardening it produces hard wear resistant surface over a strong, tough core.
- Iinterstitial solid solution are formed when the atomic radius of the solute atom is smaller than the parent metal atom.

139. Recrystallization temperature is one at which

(a) crystals first start forming from molten metal when cooled
(b) new spherical crystals first begin to form from the old deformed ones when that strained metal is heated
(c) the allotropic form changes
(d) crystals grow bigger in size

Ans. **(b)**

Sol. If a deformed polycrystalline metal is subsequently heated to a high enough temperature, new crystal nucleate and grow to consume and replace the original structure.

The temperature at which this occurs is known as recrystallization temperature.

140. Fe-C alloy containing less than 0.83% carbon is called

(a) high-speed steel
(b) hypo-eutectoid steel
(c) hyper eutectoid steel
(d) cast iron

Ans. **(b)**

Sol. Hypo-eutectoid steel (0.02 to 0.83%C)

141. Which of the following statements are correct?

1. Steel and cast iron are multi phase alloys.
2. Ferrite is a single phase interstitial solid solution of carbon in iron.
3. Wrought iron is a highly refined iron with a small amount of slag which gives resistance to progressive corrosion
4. Stellite contains large amounts of metals like cobalt and tungsten resulting in high hardness.

Select the correct answer using the code given below.

(a) 1, 2, 3 and 4
(b) 1, 2 and 3 only
(c) 1, 3 and 4 only
(d) 2 and 4 only



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Ans. **(a)**

Sol.

- Steel and cast iron may contain ferrite and cementite hence they are multiphase alloys.
- Ferrite is a single phase material which contains carbon at the interstitial site of iron atom, thus forming interstitial solid solution.
- Wrought iron is a highly refined iron with uniformly distributed quantity of slag. The non-corrosive slag constituents causes wrought iron to be resistance to progressive corrosion.
- The presence of slag produces a structure which diminishes the effect of fatigue caused by shock and vibration.

Co-based cast alloy is of trade name stellite. It typically has following composition

Co – (38 – 52%)

Cr – (30 – 32%)

W – (10 – 12%)

C – (2%)

Its structure is composed of Co-matrix, in which W-Cr carbides are embedded with volume ratio of 25–30%. It is having high hardness in the range of 58–64HRC.

142. Which one of the following statements is correct?

(a) Microprocessor is more suitable for general purpose and micro controller is more suitable for special purpose and custom built application

(b) Microprocessor and microcontroller are suitable for general purpose application

(c) Microporcessor and microcontroller and suitable for special purpose application

(d) Microprocessor and microcontroller are suitable for special purpose and custom built application

Ans. **(a)**

Sol. Microprocessor is more suitable for general purpose application

A microcontroller integrates a microprocessor with peripheral devices in an embedded system, so it is suitable for custom built and special purpose applications.

143. The unique property of cast iron is its high

(a) malleability

(b) ductility

(c) toughness

(d) damping characteristics

Ans. **(d)**

Sol. In gray cast iron, the graphite exists in the form of flakes. The flakes act as stress raises, thus reducing ductility. The graphite flakes gives the material the capacity to dampen vibration by the internal friction caused by these flakes. Hence gray cast iron is mostly used material where vibration damping is important.

144. Which one of the following pairs of tests has been developed to evaluate the fracture resistance of engineering materials, subjected to dynamic loads or impacts?

(a) Tension impacts and bending impacts

(b) Tensile test and Brinell hardness test

(c) Vickers hardness test and Tensile test

(d) Scleroscope test and file test

Ans. **(a)**

Sol. To evaluate toughness or fracture resistance of a material which are subjected to a rapidly applied load or impact, basically two types of tests are applied.

(1) Bending impacts (Charpy test, Izod test)

(2) Tension impacts (Eliminates the use of notched specimen)

145. The midpoint of a rigid link of a mechanism moves as a translation along a straight line, from rest, with a constant acceleration of 5 m/s^2. The disatnce covered by the said midpoint in 5s of motion is

(a) 124.2 m

(b) 112.5 m

(c) 96.2 m

(d) 62.5 m

Ans. (d)

Sol. distance covered = $ut+\frac{1}{2}at^2$

$u = 0,\ a = 5m/s,\ t = 5s$

$\Rightarrow$ distance covered = $\frac{1}{2}\times5\times5^2=62.5m$

146. Consider the following statements:

1. A kinematic chain is the combination of kinematic pairs joined in such a way that the relative motion between them is completely constrained.
2. The degree of freedom of a kinematic pair is given by the number of independent coordinates required to completely specify the relative movement.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (c)

Sol. A kinematic chain is the combintion of kinematic pairs joined in such a way that each link forms a part of two pairs and the relative motion between the links is completely or successfully constrained.

The degreee of freedom of a kinematic pair is given by the number of independent coordinates required to completely specify the relative movement.

147. The equation of motion for a single degree of freedom system is $4\ddot{x}+9\dot{x}+16x=0$

The critical damping coefficient for the system is

(a) $4\sqrt{2}$ (b) 4

(c) $16\sqrt{2}$ (d) 16

Ans. (d)

Sol. $4\ddot{x}+9\dot{x}+15x = 0$

$m\ddot{x}+c\dot{x}+kx = 0,\ m = 4,\ c = 9,\ k = 16$

$C_c = 2m\omega_h = 2m\sqrt{\frac{k}{m}} = 2\times4\times\sqrt{\frac{16}{4}}$

$= 2 \times 4 \times 2 = 16$

148. The mass of a single degree damped vibrating system is 7.5 kg and it makes 24 free oscillations in 14 s when disturbed from its equilibrium position. The amplitude of vibration reduces to 0.25 of its initial value after five oscillations. Then the logarithmic decrement will be

(a) $\frac{2}{5}\log_e 4$ (b) $\frac{1}{5}\log_e 6$

(c) $\frac{1}{5}\log_e 4$ (d) $\frac{2}{5}\log_e 6$

Ans. (c)

Sol. We know that

$$\frac{x_1}{x_2} = \frac{x_2}{x_3} = \frac{x_3}{x_4} = \frac{x_4}{x_5} = \frac{x_5}{x_6}$$

$$\frac{x_1}{x_6} = \frac{x_1}{x_6} \times \frac{x_2}{x_3} \times \frac{x_3}{x_4} \times \frac{x_4}{x_5} \times \frac{x_5}{x_6} = \left(\frac{x_1}{x_2}\right)^5$$

$$\Rightarrow \frac{x_1}{x_2} = \left(\frac{x_1}{x_6}\right)^{1/5} = \left(\frac{x_1}{0.25\,x_1}\right)^{1/5} = 4^{1/5}$$

Logarithmic decrement $\log_e\left(\frac{x_1}{x_2}\right)$

$$= \log_e (4)^{1/5} = \frac{1}{5}\log_e 4$$

149. A 20 kg mass is suspended from a spring which deflects 15 mm under this load. The value of the critical damping coefficient to make the motion aperiodic will be

(a) 1010 N/m/s (b) 1013 N/m/s

(c) 1018 N/m/s (d) 1023 N/m/s

Ans. **(d)**

Sol. Critical damping coefficient $C_c = 2m\omega_n$

$$= 2m\sqrt{\frac{K}{m}}$$

$$\therefore \quad C_c = 2m\sqrt{\frac{g}{\delta}} = 2 \times 20 \times \sqrt{\frac{9.81}{15 \times 10^{-3}}}$$

$$= 1023 \text{ N/m/s}$$

150. Consider the following statements:

1. The whirling (critical) speed of a shaft is that rotational speed at which the shaft so runs that the deflection of the shaft from the axis of rotation tends to become infinite/
2. Critical speed is equal to the frequency of transverse vibration of a shaft when the shaft carries a point load or a uniformly distributed load or a combination of both such loads.
3. The whirling of a shaft results from causes such as mass unbalance, hysteresis damping in the shaft, gyroscopic forces and fluid friction in the bearing

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(b)**

Sol. The speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling speed.

The critical speed of a shaft which carries point loads or uniformly distributed load or a combination of both is equal to natural frequency of transverse vibration. The centre of mass of a shaft mounted with a rotor does not generally coincide with its axis of rotation. Thus, when the shaft begins to rotate, the centre of mass of the shaft is subjected to radially outward centrifual force. This force bends the shaft in the direction of initial eccentricity of centre of mass which further increases eccentricity and hence the centrifugal force. The bending of the shaft depends on

(i) initial displacement of centre of mass and

(ii) speed of rotation of shaft