

ESE
Paper - IIPrelims Exam
Paper - II2024MECHANICAL ENGINEERING

Detailed Solution

(SET-B)

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SET - B

 Air circulates at the range of 68 kg/s and is to be heated from 16°C to 34°C. What is the water flow for an air heater coil having hot water entering at 85°C and leaving at 74°C ? (Take specific heat of air at constant pressure as 1.02 kJ/kg-K and specific heat of water as 4.187 kJ/kg-K)

(a)	19 kg/s	(b)	17	kg/s
	-			-

(c) 27 kg/s (d) 14 kg/s

Sol: (c)

Data given

$$\dot{m}_{a} = 68 \text{ kg/sec}$$
 $T_{wi} = 85^{\circ}\text{C}$
 $T_{ai} = 16^{\circ}\text{C}$ $T_{wo} = 74^{\circ}\text{C}$
 $T_{ao} = 34^{\circ}\text{C}$ $C_{pa} = 1.02 \text{ kJ/kg-K}$
 $C_{pw} = 4.18 \text{ kJ/kg-K}$
 $\dot{m}_{w} = ?$

By law of thermodynamics

$$\dot{m}_{a}C_{pa}\left(T_{ao}-T_{ai}\right)=\dot{m}_{w}C_{pw}\left(T_{wo}-T_{wi}\right)$$

or,
$$68 \times 1.02(34 - 16) = \dot{m}_{W} \times 4.18(85 - 74)$$

 $\dot{m}_w \approx 27$

- 2. A six-cylinder four-stroke diesel engine develops 125 kW at 3000 r.p.m. Its brake-specific consumption is 200 gm/kWh. What is the quantity of fuel to be injected per cycle per cylinder ? (The specific gravity of the fuel is 0.85)
 - (a) 0.0726 cc/cycle (b) 0.0379 cc/cycle
 - (c) 0.0981 cc/cycle (d) 0.0545 cc/cycle

Sol: (d)

Data given: n = 6, P = 125 kW, N = 3000 rpm

 $bsfc = 200 \text{ gm/kwh} = 200 \times 10^{-3} \text{ kg/kwh}$

$$S_{a} = 0.85$$

Fuel consumption per hour:

bsfc = $\frac{\text{fuel consumption per minute}}{\text{power}}$

or, fuel consumption per hour = bsfc (per hour) \times power

 $= 200 \times 10^{-3} \times 125 = 25 \text{ kg/hr}$

Fuel consumption per cylinder = $\frac{25}{n} = \frac{25}{6}$

= 4.17 kg/h per cylinder

Fuel consumption per cylinder per cycle

$$= 4.17 \times \frac{N}{2} = \frac{4.17 \times 3000}{2 \times 60}$$

= 4.63×10^{-5} kg/per cylinder per cycle

= 0.0463 gram/per cylinder per cycle

So quantity of fuel per cycle per cylinder = $\frac{0.0463}{0.85}$

= 0.0545 cc/cycle

3. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. What is the time ratio of cutting stroke to return stroke ?

Sol: (c)



 $90-\frac{\alpha}{2}=30$

MECHANICAL ENGINEERING



SET - B

(a)	0.415 m/s	(b)	0.586 m/s
(c)	0.302 m/s	(d)	0.845 m/s

Sol: (c)

Data given:

d = 18mm = 0.018m

N = 160 rpm

$$\omega = \frac{2\pi N}{60} = \frac{2 \times 2\pi \times 160}{60} = 16.75$$
rad/sec

Maximum velocity of sliding = $\omega \times d$

= 16.75 × 0.018 = 0.302 m/sec

6. In a thrust bearing, the external and the internal diameters of the contacting surfaces are 320 mm and 220 mm respectively. The total axial load is 80 kN. The shaft rotates at 400 r.p.m. Taking the coefficient of friction as 0.06, what is the power lost in overcoming the friction ?

(a) 26.602 kW (b) 21 kW

(c) 44.23 kW (d) 46 kW

Sol: (a)

Data given:

 $d_e = 320$ mm, $r_e = 160$ mm $d_i = 200$ mm, $r_i = 100$ mm

Total axial load is 80 kN= F

 μ = 0.06, N = 400 rpm

Effective radius of bearing,

$$\gamma_{\text{eff}} = \frac{2}{3} \left[\frac{r_{\text{e}}^3 - r_{\text{i}}^3}{r_{\text{e}}^2 - r_{\text{i}}^2} \right]$$
$$= \frac{2}{3} \times \left[\frac{(0.16)^3 - (0.1)^3}{(0.16)^2 - (0.1)^2} \right]$$
$$= \frac{2}{3} \left[\frac{3.096 \times 10^{-3}}{0.0156} \right]$$
$$= 0.1323$$

Frictional torque = $T_f = \mu \times F \times r_{eff}$

or,
$$\frac{\alpha}{2} = 60$$

or, $\alpha = 120$
 $\therefore \frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{360 - 120}{120}$
 $= \frac{240}{120} = 2$

- 4. ABCD is a four-bar chain in which link AD is the driver, link BC is the driven, and DC is fixed. The driver rotates uniformly at a speed of 120 r.p.m. and the constant driving torque is 50 N-m. At a particular phase of the mechanism, the angular velocity of the driven link is 2 rad/s. What is the ideal mechanical advantage ?
 - (a) 5.26 (b) 6.28 (c) 8.98 (d) 10

Sol: (b)



Power input = Power output

$$T_{AD} \times \omega_{AD} = T_{AB} \times \omega_{AB}$$

or,
$$MA = \frac{T_{AB}}{T_{AD}} = \frac{\omega_{AD}}{\omega_{AB}}$$
$$= \frac{2\pi \times 120}{60 \times 2} = 6.28$$

5. The distance between two parallel shaft is 18 mm and they are connected by an Oldham's coupling. The driving shaft revolves at 160 r.p.m. What is the maximum speed of sliding of the tongue of the intermediate piece along its groove ?

2024 **Detailed Solution**

MECHANICAL ENGINEERING



SET - B

9. The following data relate to two meshing gears : Velocity ratio = 1/3

Module = 4 mm

Centre distance = 200 mm

How many number of teeth are there on the gear wheels ?

(a) 90	(b)	60
--------	-----	----

(c) 45 (d) 75

Sol: (d)

V.R. =
$$1/3$$

m = 4

Centre distance = 200mm = $\frac{d_p}{2} + \frac{d_g}{2}$ $d_p + d_q = 400$(i) or, $\frac{t_g}{t_p} = \frac{d_p}{d_p} = \frac{1}{2}$

$$d_{g} = 3 \times d_{p}$$

$$m = \frac{d_{g}}{t_{g}}$$
....(ii)

so, from equation (i)

$$3d_p + d_p = 400$$

 $d_n = 100, d_n = 300$

from (ii),

&



$$= 0.06 \times 80 \times 10^3 \times 0.1323 = 635.07$$

Power loss = $T_f \times \omega$

 $\frac{635.07 \times 2\pi \times 400}{60} = 26.602 \text{ kW}$

7. The number of teeth of a spur gear is 30 and it rotates at 200 r.p.m. What is the pitch line velocity if it has a module of 2 mm ?

(a)	376.9 mm/s	(b)	628.3 mm/s
(c)	850.7 mm/s	(d)	246.1 mm/s

Sol: (b)

Rolling velocity = Pitch line velocity = $\omega \times r$

 ω = angular velocity

r = pitch circle radius

or,

SO,

Pitch line velocity = $\omega \times r = \omega \times D/2$

 $m = \frac{D}{T}$

$$= \frac{2\pi \times 200}{60} \times \frac{60}{2}$$

= 628.3 mm/sec.

 $D = 2 \times 30 = 60 \text{ mm}$

D = mT, T = 30

Two spur gears have a velocity ratio of 1/3. If the 8. driven gear has 72 teeth, then what is the number of teeth of the driver gear ?

t₁

t₁

(a)	72	(b)) 3	6
· /			,	

(c) 24 (d) 12

or,

$$t_2 = 72$$

$$V.R = 1/3$$

$$\frac{N_1}{N_2} = \frac{t_1}{t_2}$$

$$\frac{1}{3} = \frac{t_1}{72}$$

$$t_1 = 24$$

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(a) 140 r.p.m.

(c) 120 r.p.m.

 $T_A = 30, T_B = 40$ NA = 80 rpm (ccw)

10.

Sol: (a)

An epicycle gear train consists of an arm and two

gears A and B having 30 teeth and 40 teeth respectively. The arm rotates about the centre of gear A at a speed of 80 r.p.m. counterclockwise.

What is the speed of gear B if gear A is fixed ?

30

40

Rev. of arm

0

0

у

y + x = 0

y = 80

x = -80

(b) 180 r.p.m.

(d) 200 r.p.m.

A

В

Rev. B

-30/40

30 x

40

30

40

Rev. A

1

х

 $\mathbf{y} + \mathbf{x}$



SET - B

(a) 757.5 kJ	(b) 896.2 kJ
(c) 412.1 kJ	(d) 684.9 kJ

Sol: (d)

Data given

$$N_1 = 315 \text{ rpm}$$

 $N_2 = 340 \text{ rpm}$
 $K = 1.6 \text{ m}$
 $m = 3 \text{ kN}$
 $\omega_1 = \frac{315 \times 2\pi}{60} = 32.986 \text{ rad/sec}$
 $\omega_2 = \frac{2\pi \times 340}{60} = 35.604 \text{ rad/sec}$
 $I = \text{mk}^2$
 $= 3 \times (1.6)^2 = 7.68 \text{ kN.m}^2$
 $K.E. = \frac{1}{\alpha} I(\omega_2^2 - \omega_1^2)$
 $= \frac{1}{2} \times 7.68 (35.604^2 - 32.986^2)$
 $K.E. = 689.49 \text{ kg}$

12. A flywheel fitted to a steam engine has mass of 800kg. Its radius of gyration is 360 mm. The starting torque of the engine is 580 Nm and may be assumed constant. What is the kinetic energy of the flywheel after 12 seconds ?

(a)	233.27 k	J (b)	263.27 k	٢J
(~)		- (~)		

Data given: m = 800 kgk = 360 mmT = 580 N-mt = 12 sec $I = mk^2 = 103.68 \text{ kg} \cdot m^2$ $\tau = I \times \alpha$

as

 $\mathsf{B} = \mathsf{y} - \frac{30}{40}\mathsf{x}$ Speed given $= 80 - \frac{30}{12}(-80)$

A flywheel with a mass of 3 kN has a radius of 11. gyration of 1.6 m. What is the energy stored in the flywheel when its speed increases from 315 r.p.m. to 340 r.p.m. ?

SO,

S.N.

1

2

3



SET - B

$\alpha = \frac{\tau}{I} = \frac{580}{103.68} = 5.594$
$\boldsymbol{\omega}_t = \boldsymbol{\alpha}t = 5.594 \times 12 = 67.12 \text{rad/sec}$
$K.E. = \frac{1}{2}I\omega^2$
$= \frac{1}{2} \times 103.68 \times 67.12 \times 67.12$
= 233.27 kg

13. An aeroplane makes a complete half circle of 50 meters radius, towards left, when flying at 200 km/h. The rotary engine and propeller of the plane have a mass of 400 kg and radius of gyration of 0.3 m. The engine rotates at 2400 r.p.m. clockwise when viewed from the rear. What is the gyroscopic couple on the aircraft ?

(a)	10 kN-m	(b)	15 kN-m
(c)	18 kN-m	(d)	12 kN-m

Sol: (a)

V = 200 km/h = 55.55 m/sec N = 2400 rpm k = 0.3 m = 400 kg R = 50 m $\omega_{\rm P} = \frac{V}{R} = \frac{55.55}{50} = 1.111 \,\text{rad/sec}$ $\omega = \frac{2\pi N}{60} = \frac{2\pi \times 2400}{60} = 251.327 \,\text{rad/sec}$ I = mk² = 400 × (0.3) = 36 kgm² C = $I\omega_{\rm p} \times \omega$ = 36 × 1.111 × 251.327 = 100052.074 N-m \approx 10 kN-m What is the vertical height of a Watt gov

14. What is the vertical height of a Watt governor when it rotates at 60 r.p.m. ?

(a)	0.157	m	(b)	0.192 m

(c) 0.205 m (d) 0.248 m

Sol: (d)

N = 60 rpm

$$h = \frac{895}{N^2} = \frac{895}{60^2} = 0.248m$$

15. The degree of freedom (DOF) for globular or spherical pair is

(a) 1	(b) 2
(c) –1	(d) 3

Sol: (d)

Globular or spherical pair designated as G, the pair permits relative motion such that coincident point on working surface of elements move along spherical surface. In another words, for a given position of spherical pair, the joints permits relative rotation about three mutually perpendicular axes. Thus it has 3 degree of freedom.

16. Optical pyrometer works based on the principle of

- (a) conduction only
- (b) convection only
- (c) radiation
- (d) conduction and convection

Sol: (c)

The theoretical basis on which optical pyrometer works is on the stefan-boltzman law. black body radiation intensity Me

Me = σT^4

where T = thermodynamic temp.

- **17.** Consider the following common defects in steel due to heat treatment :
 - 1. Warping
 - 2. Oxidation
 - 3. Quenching cracks

Which of the above defects are correct ?

ESE 2024

MECHANICAL ENGINEERING



SET - B

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

Sol: (b)

Larson-miller parameter P = T[c + log(t)]

c = constant

T = temperature in Kelvin

t = time in hours

- **20.** Consider the following statements regarding mechanical properties of metals :
 - 1. The process of atoms moving over each other during the permanent deformation of a metal is called slip.
 - 2. An empirical equation that relates the strength of a metal to its grain size is known as Hall-Petch relationship.
 - 3. The ability of some metals to deform plastically by 1000-2000 percent at high temperatures and low loading rates is called superplasticity.

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
- Sol: (d)
- 21. The Rolls-Royce CV12 turbocharged four-stroke direct injection diesel engine has a displacement of 26.1 liters. The engine has a maximum output of 900 kW at 2300 r.pm. What is the brake mean effective pressure ?
 - (a) 18 bar (b) 15 bar
 - (c) 10.15 bar (d) 21 bar

Sol: (a)

P = 900 kw N = 2300 rpm V = 26.1 L bmep = ?

Detailed Solution

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

Sol: (d)

Most common defects in steel due to heat treatment:

- Low hardness and strength
- Soft spots
- Quench crack
- Oxidation and decarburization
- Distortion and warping
- **18.** Consider the following conditions to be fulfilled before a powder metallurgy product can be made:
 - 1. It must be possible to form a continuously bonded matrix.
 - 2. The metal in the powder from must be able to respond to solid phase welding.
 - 3. The powders in which the basic materials are available must be sufficiently close packing under pressure.

Which of the above conditions are correct ?

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

Sol: (d)

- **19.** Consider the following statements regarding mechanical properties of metals :
 - The phenomenon leading to fracture under repeated stresses having a maximum value less than the ultimate strength of material si called creep.
 - 2. A time-temperature parameter used to predict stress rupture due to creep is called Larson-Miller parameter.
 - 3. Time-dependent deformation of a material when subjected to a constant load or stress is called fatigue.

Which of the above statements is/are correct ?



SET - B

 $\frac{bmep \times V \times N}{2 \times 60} = P$ or, $\frac{bmep \times 26.1 \times 10^{-3} \times 2300}{2 \times 60} = 900 \times 10^{3}$ bmep = 1.8 MPa = 18 bar

22. A high-performance four-stroke SI engine has a compression ratio 10:1. The ideal air standard Otto cycle efficiency is 0.602. The indicated efficiency is 55 percent of the corresponding ideal air standards Otto cycle efficiency. The engine mechanical efficiency is 85 percent, and the volumetric efficiency is 90 percent. The calorific value of the fuel is 44 MJ/kg. What is the engine arbitrary overall efficiency ?

(a)	26.1%	(b)	28.1%
(c)	29.5%	(d)	30.5%

Sol: (b)

 $η_{overall} = η_{th} × η_m × η_i$ = 0.602×0.85×0.602 = 0.2814 = 28%

23. The performance test of an air-conditioning unit rated as 140.7 kW (40 TR) seems to be indicating poor cooling. The test on heat rejection to atmosphere in its condenser shown the following :

Cooling water flow rate : 4 L/s

Water temperature ; In 30°C; Out 40°C

Power input to motor : 48 kW (95% efficiency)

What is the actual refrigeration capacity of the unit? (The specific heat capacity of water is 4.1868 kJ/ kg-K)

(a)	101.5 kW	(b)	167.4 kW
(c)	121.9 kW	(d)	189.3 kW

Sol: (c)

Refrigeration capacity = 140.7 kw (40TR)

$$T_i = 30^{\circ}C$$

$$T_0 = 40^{\circ}C$$

 $V_w = 4L/sec = 0.004 \text{ m}^3/sec}$ $P_1 = 48 \text{ kw (95\% eff)}$ $\rho = \frac{m_w}{v_w}$ $1000 = \frac{m_w}{0.004}$

or, $\dot{m}_w = 4kg/sec$

Heat rejected to condenser = Q_{water}

$$= m_w c_w (T_0 - T_i)$$

= 4 × 4.1868 (40 - 30)

= 167.472 kg/sec.



- 24. If the partial pressure of water vapour for the mixture of dry air and water vapour is 12.79 mm Hg and its total pressure is 736 mm Hg, then what is the specific humidity ?
 - (a) 0.068 kg w.v./kg d.a.
 - (b) 0.011 kg w.v./kg d.a.
 - (c) 0.023 kg w.v./kg d.a.
 - (d) 0.044 kg w.v./kg d.a.

MECHANICAL ENGINEERING



SET - B

the valve ? (Consider evaporator pressure at 0° C and 7° C as 2.928 bar and 3.748 bar respectively)

(a) 2.928 bar (b) 3

(c) 0.82 bar (d) 6.676 bar

Sol: (c)

 $P_0(at \ 0^{\circ}C) = 2.928 bar$

 $P_{P}(at \ 7^{\circ}C) = 3.748 \text{ bar}$

The required pressure difference

= 3.748 - 2.928

= 0.82 bar

27. A machine working on a Carnot cycle operates between 305 K and 260 K. What is the COP when it is operated as a refrigerating machine ?

(a) 5.78	(b) 4.35
(c) 1.17	(d) 6.78

Sol: (a)

$$T_{L} = 260 \text{ K}$$

$$T_{H} = 305 \text{ K}$$

$$C_{OP} = \frac{RE}{W_{net}} = \frac{Q}{W} = \frac{T_{L}}{T_{H} - T_{L}}$$

$$= \frac{260}{305 - 260} = \frac{260}{45} = 5.78$$

28. A cold storage plant is required to store fish. The fish is supplied at a temperature of 30°C. The fish is stored in cold storage which is maintained at -8°C. If the plant requires 75 kW to drive it, what is the capacity of the plant ? (Assume actual COP of the plant as 0.3 of the Carnot COP).

(a) 40.8 TR	(b) 35.9 TR
(c) 44.8 TR	(d) 54.6 TR

Sol: (c)

$$T_L = -8^{\circ}C = 265 \text{ K}$$

 $T_H = 306 = 303 \text{ K}$

Sol: (b)

 $P_{total} = 736 \text{ mm Hg}$ $P_v = 12.79 \text{ mm Hg}$

Specific humidity = $\frac{0.622 \times P_v}{P - P_v}$

$$= \frac{0.622 \times 12.79}{730 - 12.79}$$

- = 0.011 kgwv/kgd.a
- **25.** If 1 m³ of a gas is compressed adiabatically (the ratio of specific heats = 1.4) from 1 bar to 5 bar in a reciprocating compressor, what is the work of compression ?
 - (a) 192543 N-m (b) 245361 N-m
 - (c) 158643 N-m (d) 204050 N-m

Sol: (d)

Data given:

P₁ = 1 bar, V₁ = 1 m³
P₂ = 5 bar

$$\gamma$$
 = 1.4
P_V ^{γ} = C; P₁v₁ ^{γ} = P₂v₂ ^{γ}
V₂ = $\left(\frac{1}{5}\right)^{1/\gamma}$ = 0.6325m³

$$W = \frac{\gamma}{\gamma - 1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{\gamma - 1}{\gamma}} - 1 \right]$$
$$= \frac{1.4}{1.4 - 1} \times 1 \times 1 \left[(5)^{\frac{1.4 - 1}{1.4}} - 1 \right]$$

26. An R134a thermostatic expansion valve, not equipped with an external equalizer, has a superheat setting of 7°C, while supplying the refrigerant to the evaporator at 0°C. the power fluid is same as refrigerant. What is the difference in pressure in opposite sides of the diaphragm required to open



SET - B

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(COP)_{C} = \frac{T_{L}}{T_{H} - T_{L}} = \frac{265}{303 - 265} = 6.97(COP)_{A} = 0.3 \times (COP)_{C}= 0.3 \times 6.97 = 2.091(COP)_{A} = \frac{Q_{in}}{W_{in}}2.091 = \frac{Q_{in}}{75}Q_{in} = 75 \times 2.091 = 156.9 \text{ kW}= \frac{156.9}{3.5} = 44.8 \text{TR}
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- **29.** On a particular day, the atmosphere air records a partial pressure of water vapour 9.62 mm Hg and the saturation pressure of vapour is 31.8 mm Hg. The barometric pressure is observed to be 756 mm Hg. What are the relative humidity and the specific humidity respectively ?
 - (a) 30.25%, 0.008
 (b) 30.25%, 0.014
 (c) 35.87%, 0.014
 (d) 35.87%, 0.008

Sol: (a)

Data given :

$$P_{V} = 9.62 \text{ mm Hg}$$

$$P_{S} = 31.8 \text{ mm Hg}$$

$$P_{b} = 756 \text{ mm Hg}$$

$$R_{H} = \frac{P_{V}}{P_{S}} = \frac{9.62}{31.8} = 30.25\%$$

$$W = 0.622 \frac{P_{V}}{P_{b} - P_{V}}$$

$$= \frac{0.622 \times 9.62}{745 - 9.62} = 0.008$$

30. A small water-cooled condenser uses mains water at 13°C and heats this to 24°C before it goes to waste. The evaporator duty is 4.2 kW and the motor output is 1.7 kW. What is the water mass flow ?

(a)	0.09	kg/s	(b)	0.19 kg/s
(c)	0.21	kg/s	(d)	0.13 kg/s

Sol: (d)

Evaporator duty = 4.2 kW Motar output = 1.7 kW So, Condenser load = 4.2 + 1.7 = 5.9 kW Mass flow of water = $\frac{5.9}{4.187 \times (24-13)}$ = 0.13 Kg/sec

- When a body is acted upon by pure shear stresses on two perpendicular planes, the planes inclined at 45° are subjected to
 - (a) a tensile stress of magnitude equal to that of the shear stress
 - (b) a compressive stress of magnitude equal to that of the shear stress.
 - (c) A torsional stress of magnitude equal to that of the shear stress
 - (d) a bending stress of magnitude equal to that of the shear stress.





 $\tau_{\theta} = \tau \cos 2\theta$

The resultant stress on the plane AC.

$$\sigma_{\rm r} ~=~ \sqrt{\sigma_{\theta}^2 + \tau_{\theta}^2} = \tau$$

Inclination with direction of shear stress planes.

$$\tan \phi = \frac{\sin 2\theta}{\cos 2\theta} = \tan 2\theta$$
$$\phi = 2\theta$$

The above equation shows that

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SET - B

- The normal stress is positive (tensile) when θ is between 0° and 90° and negative (compressive) between 90° and 180°.
- The shear stress is positive (clockwise) for $\theta < 45^{\circ}$ and negative (counter clockwise) for $\theta > 45^{\circ}$ and <135°.
- The shear stress is zero at 45° and 135° where the normal stress is maximum.

These conclusion indicates that when a body is acted upon by pure shear stress on two perpendicular plane inclined at 45° are subjected to tensile stress of magnitude equal to that of shear stress.

32. A piece of material is subjected to same two perpendicular tensile stresses of 100 MPa each. What is the direct stress ?

(a)	90 MPa	(b)	100 MPa
()		(-)	

- (c) 96 MPa (d) 86 MPa
- Sol: (b)



 $\sigma_y = 100 \text{ MPa}$

$$\tau_{xy} = 0$$

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

= $\frac{100 + 100}{2} + \sqrt{\left(\frac{100 - 100}{2}\right)^2 + 0^2}$
= 100 MPa

- **33.** The strain energy per unit volume required to cause the material to rupture is called
 - (a) modulus of toughness
 - (b) nodulus of rigidity

- (c) resilience
- (d) proof resilience



Ability to absorb mechanical energy upto failure is called toughness. It represents the ability to resist fracture.

Modulus of toughness

Strain energy stored upto fracture Volume of material

- **34.** Consider the following statements regarding buckling concept :
 - 1. Buckling can occur when the induced stresses are compressive such as in column.
 - 2. Buckling analysis uses the Young's modules of the material and the moment of inertia of the column cross-section, as well as its length.
 - 3. The load that buckles the column is called the crushing load.

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

Sol: (a)

Columns are vertical member carrying vertical loading and moments.

Long column fails due to buckling and analysis is done by Euler's theory which uses Youngs Modulus (E), moment of inertia (I) and length (/) for buckling analysis.

The load that buckles the column is called buckling

load and is given by $\frac{\pi^2 \text{EI}}{l_{\text{eff}}^3}$.



SET - B

- **35.** Consider the following statements regarding theories of failures :
 - Maximum principal strain theory is known as St. Venant's theory.
 - 2. Maximum shear strain energy theory is known as Mises and Hencky theory.
 - 3. Maximum strain energy theory is known as Guest and Tressca theory.

Which of the above statements are correct ?

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

Sol: (a)

Maximum principal stress theory \rightarrow Rankine theory lame's theory.

Maximum principal strain theory \rightarrow St. Venat's theory

Maxim shear stress theory \rightarrow Tresca, Guest, Coulomb theory.

Maximum strain energy theory \rightarrow Beltrami haigh theory

Maximum shear strain energy theory \rightarrow Huber-Hencky-Von Mises theory

- 36. Consider the following statements regarding beams :
 - Beams with one end fixed and the other end simply supported are known as propped cantilevers.
 - 2. Beams supported at more than two sections are known as fixed beams.
 - 3. Beams with one end fixed and the other end free are known as cantilevers.

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

Sol: (b)

The beams supported at more than two sections are known as continuous beams.



Cantilever beam

37. Consider the following statements regarding

effective length of a column :

- The effective length is the distance between the points of inflection in the deformed shape of the column, which is referred to as the elastic curve.
- 2. At the inflection point, the moment does not change sign and the member is not expected to resist any moment.
- 3. At the transition point, the curvature is changed and it is called the contraflexure point.

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

Sol: (a)

At inflection point where the deflected shape change curvature.

(BMD = 0 at this section)

However, a point where both bending moment and curvature are zero is not necessarily a point of contraflexure as they may be zero without changing signs at that point. So, statements 3 is incorrect.

- **38.** Consider the following statements regarding power transmitted through a circular shaft :
 - 1. The stress and deformation induced in the shaft can be calculated by relating power to torque.
 - The power produced by a motor is rated in terms of shaft horsepower at a specified rotational speed.



SET - B

3. Power is defined as the work done per unit time.

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

Sol: (d)

- Power from a motor is transmitted through a circular shaft.
- The stress and deformation induced in the shaft can be calculated by relating power to torque.
- Power produced by motor is rated in terms of shaft horsepower at a specific rotational speed (n).
- Power is defined as the work done per unit time.
- The speed 'n' can be measured in units of revolution per minute.
- **39.** When a body is acted upon by pure shear stress on two perpendicular planes, the planes inclined at 135° are subjected to
 - (a) a tensile stress of same magnitude with no shear stress on these planes.
 - (b) a compressive stress of same magnitude with no shear stress on these planes.
 - (c) a torsional stress of same magnitude with no shear stress on these planes
 - (d) a bending stress of same magnitude with no shear stress on these planes.

Sol: (b)



The resultant stress on the plane AC.

$$\sigma_r = \sqrt{\sigma_{\theta}^2 + \tau_{\theta}^2} = \tau$$

Inclination with direction of shear stress planes.

$$\tan \phi = \frac{\sin 2\theta}{\cos 2\theta} = \tan 2\theta$$
$$\phi = 2\theta$$

The above equation shows that

- The normal stress is positive (tensile) when θ is between 0° and 90° and negative (compressive) between 90° and 180°.
- The shear stress is positive (clockwise) for $\theta < 45^{\circ}$ and negative (counter clockwise) for $\theta > 45^{\circ}$ and <135°.
- The shear stress is zero at 45° and 135° where the normal stress is maximum.

These conclusion indicates that when a body is acted upon by pure shear stress on two perpendicular plane inclined at 45° are subjected to tensile stress of magnitude equal to that of shear stress.

While the planer inclined 135° are subjected to compressive stress of the same magnitude with no shear stress on these planer.

- **40.** Which of the following is the ability of a material to regain its original shape on removal of the applied load ?
 - (a) Proof resilience
 - (b) Resilience
 - (c) Modulus of resilience
 - (d) Gradual resilience
- Sol: (b)

Resilience of the material is the amount of energy the material can absorb and still return to its original state.

41. Which one of the following properties is not an extensive property of a system ?

ESE 2024



SET - B

Detailed Solution

- (a) Energy (b) Enthalpy
- (c) Volume (d) Temperature

Sol: (d)

Extensive property refers to a thermodynamic property of a system, whose magnitude depends on the mass of the system.

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

- 42. Two cylindrical vessels of 2 m³ each are interconnected through a pipe with a valve in between. Initially, the valve is closed and one vessel has 20 kg air while 4 kg of air is there in second vessel. Assuming the system to be at 27°C temperature initially and perfectly insulated, what is the final pressure in vessels after the valve is opened to attain equilibrium ?
 - (a) 516.6 kPa (b) 51.66 kPa
 - (c) 561.6 kPa (d) 56.16 kPa
- Sol: (a)



$$\mathsf{P}_{\mathsf{f}} = \frac{(\mathsf{m}_1 + \mathsf{m}_2)\mathsf{R}_{\mathsf{air}}}{\mathsf{V}_1 + \mathsf{V}_2} \times \mathsf{T}_{\mathsf{f}}$$

$$= \frac{(20+4)}{4} \times 0.287 \times 300$$

$$= 516.6 \, \text{kN/m}^2$$

- **43.** Thermoelectric thermometer works on the principle of
 - (a) Wheatstone bridge(b) entropy
 - (c) Seeback effect (d) ohmmeter

Sol: (c)

Thermocouple is an electrical device containing junctions of two dissimilar metal joints. It is used as temp. sensor. It works on a principle of the seeback effect.

- 44. Isentropic expansion efficiency is expressed as
 - (a) Ideal work in expansion Actual work in expansion
 - (b) Actual work in expansion + Ideal work in expansion
 - (c) Ideal work in expansion
 - ^(C) Actual work in expansion
 - (d) Actual work in expansion Ideal work in expansion

Sol: (d)

Isentropic expansion efficiency

= Actual work in expansion ideal I (isentropic) work in expansion

- **45.** In the reheat cycle, the principal advantage of reheat is to increase the quality of steam at
 - (a) turbine exhaust
 - (b) turbine inlet
 - (c) feed pump inlet
 - (d) feed pump exhaust

Sol: (a)

Reheating in Rankine cycle improves efficiency by reducing the moisture content of the steam at the end of the expansion process (i.e. turbine exhaust).

- 46. Consider the following statements :
 - 1. Viscosity of liquid increases with increase in temperature.
 - 2. Viscosity of gas decreases with increase in temperature.
 - 3. In liquids, cohesive forces predominate the molecular momentum transfer.

MECHANICAL ENGINEERING



SET - B

(a) 280 N/m²

(c) 300 N/m²

4. In gases, cohesive forces are small and the molecular momentum transfer predominates.

Which of the above statements are correct ?

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

Sol: (c)

- Viscosity of liquid decreases with increase in temperature.
- Viscosity of gases increase with increase in temperature.
- In liquid, cohesive force dominate.
- In gases, molecular momentum force dominate.
- **47.** A fluid in which shear stress is more than the yield value and shear stress is proportional to the rate of shear strain is known as
 - (a) non-ideal plastic fluid
 - (b) Newtonian fluid
 - (c) non-Newtonian fluid
 - (d) ideal plastic fluid





When shear is proportional to velocity gradient and more than yield values, fluid is known as Ideal Plastic Fluid.

48. Two horizontal plates are placed 1.25 cm apart, the space between them bearing filled with an oil of viscosity 15 poises. What is the shear stress in the oil if the upper plate is moved with a velocity of 2.5 m/s ?



(b) 260 N/m²

(d) 250 N/m²

What is the capillary rise in a glass tube of 2.0 mm diameter when immersed vertically in mercury ? (Take surface tension of mercury as 0.52 N/m. The specific gravity of mercury is 13.6 and the angle of contact is 130°)

Sol: (d)

Capillary Rise

$$h = \frac{4\sigma\cos\theta}{\rho gd}$$

 $\sigma \rightarrow$ Surface tension

 $\theta \rightarrow Angle of contact$

 $d \rightarrow Diameter$

h =
$$\frac{4 \times 0.52 \times \cos 130^{\circ}}{13600 \times 9.81 \times 2.0 \times 10^{-3}}$$
 (in SI unit)

= -0.0050 meter

h = -0.5 cm.

- 50. Consider the following statements :
 - 1. One end of piezometer is connected to the point where pressure is to be measured and the other end is open to the atmosphere.



SET - B

- Inverted U-tube differential manometer is used to measure high pressure.
- 3. U-tube differential manometer contains heavy liquid.

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
- Sol: (b)

Inverted U-tube is use measure low pressure.

51. A circular opening, 3 m diameter, in a vertical side of a tank is closed by a disc of 3 m diameter which can rotate about a horizontal diameter. What is the force on the disc if the head of water above the horizontal diameter is 5 m ?

(a)	277.4 kN	(b)	324.4 kN
(c)	311.2 kN	(d)	346.7 kN





- **52.** Consider the following statements regarding dynamics of fluid flow :
 - 1. Pitot tube is a device used to measure rate of flow of fluid through a pipe.
 - 2. Orifice meter is a device used for measuring velocity of flow at any point in a pipe.

3. Venturi meter consists of converging part, throat and diverging part.

Which of the above statements is/are correct ?

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

Sol: (c)

- Pitot tube issued to measure velocity of flow.
- Orifice meter is used to measure discharge of flow.
- Venturimeter consist of converging part, throat and diverging part.
- 53. What is the pressure gradient per meter width for the laminar flow of oil with a maximum velocity of 2 m/s between two horizontal parallel fixed plates which are 100 mm apart ? (Take a dynamic viscosity = 2.5 N-s/m²)
 - (a) -4000 N/m² per m
 - (b) -3700 N/m² per m
 - (c) -3500 N/m² per m
 - (d) $-3200 \text{ N/m}^2 \text{ per m}$
- Sol: (a)

Laminar flow of oil between two parallel plate





SET - B

- $h \rightarrow$ heat loss
 - $V \to \text{velocity}$
 - ${\it I} \rightarrow {\rm length}~{\rm of}~{\rm pipe}$
 - $d \rightarrow diameter \ of \ pipe$
- $f \rightarrow coefficient of friction.$

h =
$$\frac{0.005 \times 4 \times 100 \times 5^2}{2 \times 9.81 \times 0.3}$$

h = 84.94 m

- 56. Consider the following statements :
 - 1. The apparent viscosity of a pseudoplastic fluid decreases with decrease in the shear rate.
 - 2. The apparent viscosity of a dilatant fluid increases with increase in the shear rate.
 - 3. Bingham plastic fluid requires a finite yield stress before beginning to flow.
 - (a) 1 and 2 only (b) 1 and 3 only
 - (c) 2 and 3 only (d) 1, 2 and 3

Sol: (c)



Statement (2) and (3) are correct.

For pseudo plastic apparent viscosity decreases with increase in shear rate.

Hence, correct option is (c)

57. The dimensional formula of bulk modulus of elasticity in MLT notation system is

(a) MLT ⁻¹	(b) M ⁻¹ LT ²	
(c) ML ⁻¹ T ⁻¹	(d) ML ⁻¹ T ⁻²	

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 $= \frac{2}{3} \times 2 = \frac{4}{3} \frac{m}{\text{sec}}$ So, $\left(\frac{p_1 - p_2}{\ell}\right) = \frac{12 \times 2.5 \times 4}{3 \times (0.1)^2}$ = 4000 N/m² per m

- **54.** Consider the following statements regarding dynamics of fluid flow :
 - Kinetic energy correction factor is defined as the ratio of kinetic energy of the flow per second based on actual velocity to kinetic energy of the flow per second based on average velocity.
 - Kinetic energy correction factor is defined as the ratio of kinetic energy of the flow per second based on average velocity to kinetic energy of the flow per second based on maximum velocity.
 - Momentum correction factor is defined as the ratio of momentum of the flow per second based on actual velocity to momentum of the flow per second based on average velocity.
 - Momentum correction factor is defined as the action of momentum of the flow per second based on average velocity to momentum of the flow per second based on maximum velocity.

Which of the above statements are correct ?

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

Sol: (b)

55. An oil is flowing through a pipe of diameter 300 mm with velocity of 5 m/s. What is the head loss to maintain the flow for a length of 1000 m ? (Take coefficient of friction = 0.005)

(a)	60.2 m	(b)	72.4 m
(c)	76.7 m	(d)	84.9 m

Sol: (d)

$$h = \frac{4f/V^2}{2gd}$$

2024 **Detailed Solution**

Bulk modulus, K = $\frac{P}{\Delta V/V}$

conventions in stress analysis :

is negative.

 $= \frac{ML^{-1}T^{-2}}{L^{3}/L^{3}} = ML^{-1}T^{-2}$

Consider the following statements regarding general

1. Tensile stress is positive and compressive stress

2. A pair of shear stresses on parallel planes

3. Clockwise angle is taken as negative and

counterclockwise couple is positive.

Which of the above statements are correct ?

forming a clockwise couple is positive and a

pair with a counterclockwise couple is negative.

(b) 1 and 3 only

(d) 1, 2 and 3



SET - B

- 2. The superposition principle applies to all parameters like stress, strain and deflection.
- 3. The superposition principle is applicable to materials with non-linear stress-strain characteristic, which do not follow Hooke's law.

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

Sol: (a)

The superposition principle is applicable to materials with linear stress-strain characteristic and follows Hooke's law.

So, statement 3 is incorrect.

- 60. Rails are laid such that they have no stress at 24°C. What is the stress in the rails at 80°C, when there is no allowance for expansion ? (Assume coefficient of linear expansion = $11 \times 10^{-6} \circ C^{-1}$ and Young's modulus of rails metal = 205 GPa)
 - (a) 126.28 MPa (b) 251.84 MPa
 - (c) 296.72 MPa (d) 325.35 MPa

Sol: (a)

$$\frac{\sigma}{E} = \alpha \Delta T$$

$$\sigma = E \alpha \Delta T$$

$$= 205 \times 10^9 \times 11 \times 10^{-6} \times (80 - 24) Pa$$

$$= 126280 \times 10^3 Pa$$

$$= 126.28 MPa$$

- Consider that the Rankine cycle efficiency is 61. improved in the following ways :
 - By reducing heat addition in boiler 1.
 - By increasing stream turbine expansion work 2.
 - 3. By reducing feed pump work.

Which of the above are correct ?



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Sol: (b)

Sol: (d)

58.

Sign Convention :

(a) 1 and 2 only

(c) 2 and 3 only

Tensile stress is (+)ve

Compression stress is (-)ve



Anticlockwise rotation is (+)ve

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Clockwise rotation is (-)ve
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- 59. Consider the following statements regarding principle of superposition :
 - 1. The principle of superposition states that if a body is acted upon by a number of loads on various segments of the body, then the net effect on the body is the sum of the effects caused by each of the loads acting independently on the respective segment of the body.



SET - B

$$\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} + \frac{d^2T}{dz^2} = 0$$

For 2-dimensional heat generate

$$\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} = 0$$

- Which one of the following expressions is correct 64. about the relation among Grash of number (Gr), Prandtl number (Pr) and Rayleigh number (Ra)?
 - (a) Ra = Gr Pr (b) Gr = Ra Pr (c) Ra = Gr - Pr(d) Gr = Ra - Pr

Sol: (a)

- 65. An order-of-magnitude analysis of the free convection boundary layer equations will indicate a general criterion for determining whether free convection effects dominate. The criterion is that when
 - (a) $Gr/Re^2 < 10$, then free convection is of primary importance
 - (b) $Gr/Re^2 = 10$ then free convection is of primary importance
 - (c) $Gr/Re^2 > 10$, then free convection is of primary importance.
 - (d) $Gr/Re^2 > 10$, then forced convection is of primary importance.

$$\frac{\text{Gr}}{\text{Re}^2} \ge 1$$
: Pure free convection

$$\frac{\text{Gr}}{\text{Re}^2} = 1$$
: Mixed convection

$$\frac{\text{Gr}}{\text{Re}^2} \le 1$$
: Pure forced convection

66. If the monochromatic emissivity of a body si independent of wavelength, it is called

Detailed Solution

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

 $\eta_{th} = f(T_m)$ So, by heat addition $T_m \uparrow$, so $\eta_{th} \uparrow$

What is the actual pressure of air in the tank if the 62. pressure of compressed air measured by manometer is 30 cm of mercury and atmospheric pressure is 101 kPa ? (Take $g = 9.78 \text{ m/s}^2$ and density of mercury at room temperature as 13550 kg/m³)

(a)	140.76 GPa	(b)	140.76 MPa

(c) 140.76 kPa (d) 140.76 Pa

Sol: (c)



$$P_{air} = P_{atm} + \rho_m gh_m$$

= 101kPa+ $\left(\frac{13550 \times 9.78 \times 0.3}{100}\right)$
 $P_{air} = 140.76 \text{ kPa}$

The equation for two-dimensional steady-state 63. conduction without heat sources is

(a)
$$\frac{d^2T}{dr^2} + \frac{q}{k} = 0$$
 (b) $\frac{d^2T}{dx^2} + \frac{1}{r}\frac{dT}{dr} = 0$
(c) $\frac{d^2T}{dx^2} = 0$ (d) $\frac{\partial^2T}{\partial x^2} + \frac{\partial^2T}{\partial y^2} = 0$

Sol: (d)

General steady state heat conduction without heat generation is



SET - B

- (a) transparent body (b) reflective body
- (c) black body (d) gray body

Sol: (d)

A surface whose emissivity is independent of direction and wavelength is known as diffuse gray body.

67. Which one of the fallowing equations is called Kirchoff's identity ?

(a)
$$\varepsilon = \frac{E}{E_b}$$
 (b) $\varepsilon = \frac{E_b}{E}$
(c) $\varepsilon = \infty$ (d) $\varepsilon = 1$

Sol: (a)

Kirchhoff's identity equation $\frac{E}{E_b} = \epsilon$

i.e. $\varepsilon = \alpha$.

68. The interface angles of rhombohedral crystal systems are

(a) $\alpha = \beta = \gamma \neq 90^{\circ}$ (b) $\alpha = \beta = \gamma = 90^{\circ}$ (c) $\alpha = \beta = 90^{\circ} \neq \gamma$ (d) $\alpha = \beta = 90^{\circ}; \gamma = 120^{\circ}$

Sol: (a)

Rhombohedral, a = b = c, $\alpha = \beta = \gamma \neq 90^{\circ}$

Hexagonal, $a = b \neq c$, $\alpha = \beta = 90^{\circ}$, $\gamma = 120^{\circ}$

- **69.** Consider the following statements for characteristics of ionic compounds :
 - 1. Ionic compounds are general crystalline in nature and rigid.
 - 2. They are generally nonconductor of electricity.
 - 3. They are insoluble in organic solvents, but highly soluble water.

Which of the above statements are correct ?

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

Sol: (c)

lonic compounds are crystalline, hard rigid and highly soluble in water.

They are conductor of electricity.

- **70.** Consider the following statements for the characteristics of covalent compounds :
 - 1. They can exist in all states of matter.
 - 2. They are generally electric insulators.
 - 3. They are insoluble in water, but soluble in nonpolar solvents such as benzene and alcohol, etc.

Which of the above statements are correct ?

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

Sol: (c)

- Covalent compound are normally solid, liquid and gases.
- They are poor conductor of electricity.
- Covalent compounds are less polar or non polar and insoluble in nature.
- 71. Consider the following statements :
 - 1. X-rays are not deflected by electric or magnetic fields.
 - 2. They produce fluorescence in many substances.
 - 3. They are highly penetrating and destructive on living tissues on excessive exposure.

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
- Sol: (d)
 - X-ray are not deflected by electrons and magnetic field because X-ray do not carry charge. They are electromagnetic radiations and therefore cannot be deflected by electronic or magnetic field.



SET - B

- X-ray can also cause certain substance to fluorescence or emit radiation of longer wavelength. Because of this they are used in medicine, industry and research.
- They cause damage of tissue.

72. Consider the following statements :

The application of X-rays in scientific research is

- 1. to investigate the structure of crystalline solids
- 2. to study complex organic compounds by analyzing their structures
- 3. to find the atomic numbers and energy levels to identify the elements.

Which of the above statements are correct ?

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

Sol: (d)

- X-ray diffraction analysis (XRD) is used for characterization of new particles. It gives information regarding crystal structure, nature of phase.
- X-ray data demonstrates a physical property, the atomic number.
- X-ray crystallograph is currently the most favoured technique for structure determination of proteins and biological macromolecules.
- 73. Consider the following statements :

The influence of molybdenum element in steels.

- 1. imparts higher temperature strength
- 2. enhances resistance to creep
- 3. minimizes temperature brittleness

Which of the above statements is/are correct ?

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

Sol: (c)

Molybdenum (Mo) increase strength, hardenability and toughness, as well as creap resistance and strength at higher temp. is steel.

Upto 0.7% Mo, \uparrow the temper embrittlement in steel beyond this it has reverse effect. For steel parts working in the high temp. range, it is difficult to prevent embrittlement by adding molybdenum.

- **74.** The alloying elements of tungsten-based tool steels are
 - (a) Cr, V, Co and W (b) Cr and V only
 - (c) Cr, Ni and Mo (d) Cr, W, V and Mo

Sol: (a)

Alloying element is tungsten-steel is the Carbon, tungsten, cobalt, chromium and vanadium.

- **75.** Consider the following disadvantage of LAUE methods :
 - 1. Various reflections may make the appearance of the photograph complicated.
 - 2. Due to the wide range of wavelengths, there is overlapping of diffraction images.
 - 3. There is a variation of incident X-ray beam due to the large range of wavelengths.

Which of the above disadvantages is/are correct ?

- (a) 1 and 3 only (b) 1 and 2 only
- (c) 3 only (d) 1, 2 and 3
- Sol: (b)
- **76.** Consider the following statements regarding tidal energy :
 - 1. When the sun-earth and moon earth directions are perpendicular, the solar and lunar tides are out of phase producing net tides of maximum range.
 - 2. Neap tides occur twice per month at times of half-moon.
 - 3. Spring times occur twice per lunar month at times of both full and new moon.



SET - B

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 $\,$

Sol: (d)

- **77.** Consider the following statements regarding phosphoric acid fuel cell :
 - The basic phosphoric acid fuel cell consists of two electrodes of porous conducting material to collect charge.
 - 2. At the negative electrode, hydrogen gas is converted to hydrogen ions.
 - 3. Pure hydrogen or a hydrogen-rich gas is supplied at positive electrode and oxygen or air is supplied at negative electrode.

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 $\,$

Sol: (a)

Pure hydrogen or hydrogen rich gas is supplied at the negative electrode and oxygen at the positive electrode.

- **78.** Consider the following statements regarding visual perception :
 - 1. Vision is the most important sensory channel for humans.
 - 2. The function of visual perception is to provide visual input to support a robot's learning process.
 - 3. Vision plays a vital role in any machine which intends to perform autonomous motions.

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

Sol: (d)

In similar manner, vision plays a vital role in any machine which intends to perform autonomous motion, action, task or even behaviour, vision is the most sensory channel for humans (as well as for animals). One of the function of visual perception is to provide visual input to support robot's learning process.

- 79. Trajectory is a path
 - (a) without time constraint
 - (b) with time constraint
 - (c) in one-dimensional space
 - (d) with a motion planning strategy

Sol: (b)

Trajectory is the path that moving object follows through space as function of time. Trajectory means a time based profile of position and velocity from start to destination while path based on non-time parameters.

- 80. Collision-free path of the trajectory requires
 - (a) constrained motion of the work space
 - (b) time constraint
 - (c) geometric model of the workspace
 - (d) kineto-dynamic chain

Sol: (c)

Motion execution implies the execution of motion in a safe manner. Therefore, the path or trajectory to be followed by end-effector's from should not intersect with any other object in a scene or workspace. The determination of a collision-free path trajectory is not easy because it requires advance knowledge of the geometric model of workspace.

- **81.** The purpose of defuzzification is to make a decision based on
 - (a) fuzzy output set (b) fuzzy input set
 - (c) Boolean set (d) motion set

Sol: (b)

ESE MECHAI 2024



SET - B

Sol: (d)

- A joint is the connection between two or more links at their node.
- If a joint connect only two links, the entity is also called a kinematic pair.
- In three-dimensional space, any complex motion with reference coordinate system can be treated as combination of two basic motions, translational and rotation. Therefore, in one DOF.
 Joint impose a translation motion is called as prismatic joints.
- 84. HARO-1 is
 - (a) a prototype of robotic animal
 - (b) a prototype of human-like robot
 - (c) a prototype of robotic engine
 - (d) a prototype of robotic bird

Sol: (b)

HARO-1 is a prototype of a human like robot.

- **85.** Consider the following statements regarding sensing elements :
 - 1. A human sensory system can be divided into five distinct sub-systems.
 - 2. MEMS stands for 'Micro-Electro-Mechanical System'.
 - 3. The walking procedure involves unpredictable movement done by a robot.

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

Sol: (d)

- A human sensory system can be divided into five distinct subsystems, namely: Visual, Auditory, Kinesiatrics, Gustatory and Olfactory.
- MEMS (Micro electrical mechanical system) is a miniature machine that has both mechanical and electronic components.

Defuzzification is used to transfer fuzzy inference results into a crisp output. In another word it is realized by a decision-making algorithm that select the best crips value based on a fuzzy set.

Detailed Solution

- **82.** Consider the following statements regarding issues in robotics :
 - 1. A robot's degree of autonomy depends on its ability to perform the ordered sequence of perception, decision-making and action.
 - 2. Kinematics is the study of motion in relation to force and torque.
 - 3. Dynamics is the study of motion without consideration of force and torque.

Which of the above statements is/are correct ?

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

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

Sol: (a)

- Robot is a physical agent which is capable of executing motion for the achievement of tasks.
- A robot's degree of autonomy depends on its ability to perform the ordered sequence of perception, decision making and action.
- Kinematic is the study of motion without consideration of force and torque, while dynamic is the study of motion in relation to force and torque.
- 83. Consider the following statements regarding joints :
 - 1. A joint is the connection between two or more links at their nodes.
 - 2. If a joint connects only two links, the entity is also called a kinematic pair.
 - 3. If a one degree of freedom joint imposes a translational motion, it is called a prismatic joint.

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



SET - B

- Remote triggering of walking robots involves complex mechanical system that require further simplification.
- **86.** The physical quantities related to touch are measured by
 - (a) simple sensors (b) reflective sensors
 - (c) tactile sensors (d) touch sensors

Sol: (d)

Touch Sensor : A touch senser is on electronic device that detects physical contact or pressure.

- **87.** Consider the following statements regarding joint-space control :
 - 1. The motion performed by a robot is the input motion of its mechanism.
 - 2. The control scheme at the lowest level of a robot's motion control system is called joint-space control.
 - 3. A robot is a machine which is skilled at executing motions.

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

Sol: (c)

Robot is a machine which is skilled at executing motions. The motion performed by a robot is the output motion of its mechanism.

- 88. Autonomy is a characteristic which describes
 - (a) an automated system's degree of independence
 - (b) an automated system's degree of freedom.
 - (c) au automated behavior
 - (d) an automated action

Sol: (a)

Autonomy is a characteristics which describes on automated systems degree (or level) of independence.

- **89.** Consider the following statements regarding monocular vision :
 - 1. The monocular vision system takes images as input, and produces geometrical measurement as output.
 - 2. A monocular vision system is normally composed of a single electronic camera, an image digitizer and computing hardware.
 - 3. The electrical signals, picked up by the imaging sensor of the camera, will be converted into an analogue image.

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

Sol: (d)

- 90. The function of parallel splitter motion is to
 - (a) duplicate the input motion into multiple motions
 - (b) duplicate the split input motion into multiple parallel input motions
 - (c) duplicate the split input motion into multiple random input motions
 - (d) duplicate the multiple random input motions into single input motion

Sol: (b)

The purpose of a motion splitter is to duplicate the input motion into multiple output motions. The input rotary motion to a motion splitter comes from the output motion of a single motor. This method consist of using a planer-gear mechanism to split the input motion into multiple output motions at multiple output shafts which are positioned in parallel (i.e. their axes of rotation are parallel). A device implementing this method is called a parallel splitter of motion.

- **91.** In which one of the following casting processes, thin slabs are produced from molten metal ?
 - (a) Gravity die casting
 - (b) Centrifugal casting

MECHANICAL ENGINEERING



SET - B

- (c) Plaster casting
- (d) Strip casting

Sol: (d)

In **strip casting**, thin slabs, or strips, are produced from molten metal. The metal solidifies in similar manner to strand casting, but the hot solid is then rolled to produce the final shape. The compressive stress in rolling serve to reduce porosity and to provide better material properties In effect, strip casting eliminates a hot-rolling operation in the production of metal strips or slabs.

- 92. Consider the following statements regarding forging :
 - 1. In incremental forging process, a tool forges a blank into a shape in several small steps.
 - 2. In isothermal forging process, the process heats the dies to the same temperature as that of the hot workpiece.
 - 3. In rotary swagging process, a solid rod is subjected to radial impact forces by a set of reciprocating dies of the machine.

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

- Sol: (d)
- **93.** Which one of the following instruments is commonly used for measuring the thickness and inside or outside dimensions of parts ?
- (a) Micrometer (b) Anvil
 - (c) Sine bar (d) Surface plate

Sol: (a)

Micrometers instruments are commonly used for measuring the thickness and inside or outside dimensions of parts. digital micrometeres are equipped with readers (Fig. (a)), either in metric or in English units. Micrometers also are available for measuring internal diameters (inside micrometer) and depths (micrometer depth gage, Fig. (b)). The anvils or micrometers can be equipped with conical or ball contacts, to measure recesses, threadedrod diameters, and wall thicknesses of tube and curved sheets or plates.



Figure (a)



Figure (b)

- **94.** The technique that creates a three dimensional image of the part by utilizing an optical system is called
 - (a) thermal inspection
 - (b) eddy current inspection
 - (c) holography
 - (d) radiography
- Sol: (c)

The holography technique creates a threedimensional image of the part by utilizing an optical system. Generally used on simple shape and highly polished surfaces, this technique records the image on a photographic film.

The use of holography has been extended to holographic interferometry for the inspection of parts with various shapes and surface features. Using double and multiple exposure techniques, MECHANICAL ENGINEERING



ESE 2024 Detailed Solution

SET - B

while the part is being subjected to external forces or time dependent variations, any changes in the images reveal defects in the part.



Fig. Schematic illustration of the basic optical system used in holography elements in radiography for detecting flaws.

- Acoustic holography. Information on internal defects is obtained directly from the image of the interior of the part. In liquid-surface acoustical holography, the part and two ultrasonic transducers (one for the object beam and the other for the reference beam) are immersed in a water-filled tank. A holographic image is then obtained from the ripples in the tank.
- Scanning acoustical holography. Only one transducer is used and a hologram is produced by electronic-phase detection. In addition to being more sensitive, the equipment is usually portable and can accommodate very large workpieces by using a water column instead of a tank.
- 95. The welding flame with excess oxygen is known as
 - (a) oxidizing flame (b) carburizing flame
 - (c) reducing flame (d) neutral flame

Sol: (a)



Oxidizing Flame: Once the neutral flame is establish and now the oxygen quantity is increases then oxidizing flame establish or when more than the one part of oxygen (O_2) is mixing with one part of Acetylene (C_2H_2) in the gas torch and burning a flame is generating at the torch tip resultant flame is define as oxidizing flame. This flame also consist a outer envelope and inner cone but now the temperature of inner cone is 3500°C means it is hotter than neutral flame. An oxidizing flame burns with a decided loud roar. This type of flame is limited for use only for

- (i) Copper base metal
- (ii) Zinc base metal

It is not applicable for steel welding.

- **96.** Consider the following statements regarding solar energy :
 - 1. The sun radiates energy uniformly in all directions in the form of electromagnetic waves.
 - 2. The output of the sun is 2.8×10^{23} kW.
 - 3. The energy reaching the earth is 1.1×10^{12} kWh/year.

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
- Sol: (a)

Energy reaching the earth is 1.5×10^{18} Kwh/year.

- **97.** Consider the following statements regarding measurement of solar radiation :
 - 1. Pyranometer cannot measure diffuse radiation.
 - 2. Pyrheliometer is an instrument that measures beam radiation.
 - 3. A sunshine recorder measures the sunshine hours in a day.

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

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SET - B

Sol: (c)

Pyranometer is a device that can be used to measure both beam radiation and diffuse radiation.

- 98. Consider the following statements :
 - 1. The sum of beam and diffuse radiation is referred to as global radiation.
 - 2. Diffuse radiation does not have a unique direction.
 - 3. Solar radiation propagating in a straight line and received at the earth surface without change of direction is called direct radiation.

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

Sol: (d)

Solar radiation propagating in a straight line and received at the earth's surface without change of direction is called beam or direct radiation.

- **99.** Consider the following statements regarding depletion of solar radiation :
 - 1. Nitrogen gas absorbs the X-rays and extreme ultraviolet radiations.
 - 2. Dust particles and air molecules absorb a part of solar radiant energy irrespective of wavelength.
 - 3. Ozone cannot absorb ultraviolet radiation.

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

Sol: (a)

Ozone is a particularly effective absorber of UV radiation.

- 100. Consider the following statements :
 - 1. Solar radiation incident on the outer atmosphere of the earth is known as extra radiation.

- 2. Solar radiation that reaches the earth surface after passing through the earth's atmosphere is known as terrestrial radiation.
- 3. The term 'solar insolation' is defined as solar radiation energy received on a given surface area in a given time.

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

Sol: (d)

- **101.** Consider the following statements regarding solar collectors :
 - Collector efficiency is defined as the ratio of the energy actually absorbed and transferred to heat-transporting fluid by the collector to the energy incident on the collector.
 - 2. Concentration ratio is defined as the ratio of the area of the receiver to the area of aperture of the system.
 - 3. Temperature range is the range of temperature to which the heat-transporting fluid is heated up the collector.

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

Sol: (c)

Collector Efficiency : It is the ratio of the amount of useful heat collected to the total amount of solar radiation striking the collector surface during any period of time.

- 102. Consider the following statements :
 - 1. The concentration ratio achieved from compound parabolic concentrator is in the range of 3-7.
 - 2. The concentration ratio in the rang of 70-80 may be achieved from cylindrical parabolic concentrator collector.



SET - B

3. A concentration ratio of 10-30 may be achieved from linear Fresnel lens collector which yields temperature between 150°C and 300°C.

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

Sol: (c)

Compound parabolic concentrator is the type of nonimaging concentrator and its concentration ratio is low as 2-5.

- **103.** Consider the following statements regarding solar greenhouse :
 - 1. If natural means are adopted to collect, store and distribute the energy inside, it is known as active greenhouse.
 - 2. In cold countries, 'winter greenhouses' provide supplementary heat to maintain adequate temperature during cold months when solar insolation is low.
 - 3. Greenhouse for arid zone are designed to conserve water resources.

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

Sol: (c)

If natural means are adopted to collect, store and distribute the energy inside, it is known as passive green house.

- **104.** Consider the following statements regarding wind energy :
 - 1. The rate of change of wind speed with height is called wind shear.
 - 2. The layer of air from ground to gradient height is known as planetary boundary layer.
 - 3. In the surface layer, the mean wind speed with height can be represented by Prandtl logarithmic law model.

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

Sol: (a)

Ekman Layer : It is the air layer form surface layer (100 m) that extends up to the gradient height. The variation of shear stress can be neglected in this layer and the mean wind speed with height can be given by Prandtl number.

- **105.** Consider the following statements regarding biomass energy :
 - Charcoal is obtained by biomization process of woody biomass to achieve higher energy enthalpy per unit mass.
 - 2. Biodiesel is simple to use, biodegradable and non-toxic.
 - 3. The raw vegetable oil is upgraded as biodiesel through a chemical process called transesterification.

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

Sol: (c)

Biodiesel is simple to use, biodegradable non toxic and essentially free of sulphur and aromatics.

- **106.** Consider the following statements regarding low-cycle and high-cycle fatigue:
 - 1. Any fatigue failure, when the number of stress cycles is less than 1000, is called low-cycle fatigue.
 - 2. Any fatigue failure, when the number of stress cycles is more than 1000, is called high-cycle fatigue.
 - 3. The high-cycle fatigue involves plastic yielding at localized areas of the components.

Which of the above statements are correct?

ESE 2024

MECHANICAL ENGINEERING



SET - B

109. A pair of spur gears consists of a 20 teeth pinion meshing with a 120 teeth gear. The module is 4mm. What is the centre distance?

(a) 210 mm	(b) 280 mm
(c) 310 mm	(d) 325 mm

Sol: (b)

Data given :

 $T_P = 20$, $T_G = 120$, Module, m =4 mm

Centre distance between two gears 1, 2 is given by

C =
$$r_P + r_G$$

= $\frac{m}{2}(T_P + T_G)$
= $\frac{4}{2} \times (20 + 120) = 280 \text{ mm}$

- **110.** In a particular application, the expected life for 90% of the bearings is 8000 h. What is the rated bearing life when the shaft rotates at 1450 r.p.m?
 - (a) 607 million revolutions
 - (b) 641 million revolutions
 - (c) 696 million revolutions
 - (d) 712 million revolutions

Sol: (c)

 $L_{10b} = 8000$ hr, N = 1450 rpm.

Life of a bearing corresponds to 90% reliability

= 60 NL_H = 60 × 1450 × 8000

- = 696 million revolution
- **111.** Consider the following statements:
 - 1. Zero film bearing is a bearing which operates without any lubricant.
 - Thin film lubrication describes a condition, where two surfaces of the bearing in relative motion are completely separated by a film of fluid.

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Detailed Solution

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

Sol: (a)

Failure with fluctuating stress that are high enough to cause failure in few thousand cycle (<1000) is called low-cycle fatigue. Plastic yielding at localized areas may be involved.

- **107.** Consider the following statements regarding joints:
 - 1. Bolted joint is the example of permanent joint.
 - 2. Cotter joint is the example of separable joint.
 - 3. In hand riveting, a die is placed on the protruding end of the shank and blows are applied by a hammer

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 $\,$

Sol: (c)

- **108.** Consider the following statements regarding transmission shaft:
 - 1. Countershaft is a secondary shaft, which is driven by the main shaft and from which the power is supplied to a machine component.
 - Spindle consists of a number of shafts, which are connected in axial direction by means of couplings.
 - 3. Jackshaft is an auxiliary shaft between two shafts that are used in transmission of power.

Which of the above statements are correct?

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

(c) 2 and 3	only (d)	1,	2	and	3
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Sol: (b)

A line shaft consist of a number of shaft, which are connected to an axial direction by means of coupling.

MECHANICAL ENGINEERING



SET - B

- k = 0.3535m $l_{d} = m_{d}k^{2}$ $= 1130.97 \times (0.3535)^{2}$ $= 141.2872 \text{ kg-m}^{2}$ Energy absorbed $= \frac{1}{2}l_{d}\omega^{2}$ $= \frac{1}{2} \times 141.2872 \times (36.65)^{2}$ = 94 kJ
- **114.** Consider the following statements regarding functions of flywheel:
 - 1. It stores and releases energy when needed during the work cycle.
 - 2. It increases the power capacity of the electric motor or engine.
 - 3. It reduces the amplitude of speed fluctuations.

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

Sol: (d)

- **115.** Consider the following statements:
 - 1. The governor controls the mean speed of the engine by varying the fuel supply to the engine.
 - 2. The flywheel has no influence on the mean speed of the engine.
 - 3. A flywheel may be used if the cyclic fluctuations of energy output are negligible.

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

Sol: (b)

Flywheel doesn't maintain constant speed, it simply reduces fluctuation of speed.

Detailed Solution

2024

 Hydrodynamic lubrication is defined as a system of lubrication in which the load-supporting fluid film is created by the shape and relative motion of the sliding surfaces.

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 $\,$

Sol: (b)

Thick film lubrication is the condition of lubrication where two surfaces of the bearing are completely separated by the film of liquid.

- **112.** Consider the following statements regarding lubricant:
 - 1. Molybdenum disulphide is semi-solid lubricant.
 - 2. It is used to protect bearing from corrosion.
 - 3. It is used to reduced wear.

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 $\,$

Sol: (c)

Molybdenum disulphide is a solid lubricants and semi solid lubricants are greases and liquid etc.

113. A solid cast iron disc, 1130.97 kg mass, is used as flywheel. The radius of gyration of the solid disc is 0.3535 m about its axis of rotation. It is rotating at an angular speed of 36.65 rad/s and brought to rest by means of a brake. The energy absorbed by the brake is

(a)	61	k.l	(b)	76	k.l
(a)	01	ĸJ	(u)	10	ĸJ

- (c) 94 kJ (d) 107 kJ
- Sol: (c)

Data given :

$$M_{d} = 1130.97 \text{ kg}$$

$$\omega$$
 = 36.65 rad/sec



SET - B

116. The yearly duration curve of a certain power plant can be considered as a straight line from 350 MW to 80 MW. Power is supplied with one generating unit of 250 MW capacity and two units of 150 MW capacity each. What is the utilization factor?

(a)	0.436	(b)	0.536
(4)	0.100	(~)	0.000

- (c) 0.636 (d) 0.736
- Sol: (c)
 - Utilization factor = $\frac{\text{Maximum load}}{\text{Rated capacity}}$ Maximum load = 350 MW Rated Capacity = $250 + 2 \times 150$ = 250 + 300 = 550Utilization factor = $\frac{350}{550} = 0.636$
- 117. Which one of the following is Dulong's formula for the calculation of the calorific value of the solid or liquid fuels from their chemical composition? (Where H, O and S are hydrogen, oxygen and sulphur in percentage respectively in 100 kg of fuel)

(a)
$$HCV = \frac{1}{100} [13800 + 144000 \left\{ H - \frac{O}{8} \right\} + 7270S] kJ/kg$$

(b) HCV =
$$\frac{1}{100}$$
 [23800 + 144000 $\left\{H - \frac{O}{8}\right\}$ + 8270S] kJ / kg

- (c) $HCV = \frac{1}{100} [33800 + 144000 \left\{ H \frac{O}{8} \right\} + 9270S] kJ / kg$
- (d) None of the above

Sol: (d)

Determination of calorific value from Dulong formula. Calorific value =

 $\frac{1}{100} \Big[8080C + 34500 (H - O/8 + 2240S) \Big] \text{Kcal/Kg}$

where C, H, O and S refers to the percentage of Carbon, hydrogen, oxygen and sulphur, respectively.

118. Consider the following statements regarding steam turbines:

- 1. In reaction turbine, the steam expands in the stationary nozzles and attains high velocity.
- 2. In impulse turbine, the steam enters the fast moving blades on the rotor from stationary nozzles; if the steam is superheated before allowing it to expand, the Rankine cycle efficiency may be increased.
- In impulse turbine, the resulting high velocity steam impinges against the blades which alter the direction of steam jet thus changing the momentum of jet and causing impulsive force on the blades.
- 4. In steam turbine, the steam consumption does not increase with increase in years of service.

Which of the above statements are correct?

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

Sol: (b)

- In reaction turbine, the steam expands in both stationary and moving blades.
- The steam consumption per hour per kilowatt of power developed is less and does not increase oven the year, i.e., the specific steam consumption is less.
- **119.** The overall thermal efficiency of a 40 MW turbo alternator is 30%. If the load factor of the power station is 50% and the coal burnt has a calorific value of 6800 kcal, what is the energy produced per day?

(a)	44×10 ⁴ kWh	(b)	48×10 ⁴ kWh
(c)	34×10 ⁴ kWh	(d)	38×10 ⁴ kWh

Sol: (b)

Data given $\eta_{overall} = 30\%$

Load factor = 50%

= Average demand Maximum demand



SET - B

Energy produced = Load factor \times 40 \times 24

$$= \frac{50}{100} \times 40 \times 24 \times 10^4$$

= 48 x 10⁴ kWh

- **120.** Consider the following statements regarding steam power plants:
 - 1. An increase in the initial pressure of steam raises the thermal efficiency.
 - 2. The thermal efficiency will be dropped by raising the initial temperature of the steam without changing the pressure.
 - 3. Intermediate reheating of steam improves the thermal efficiency of the plant.
 - 4. An increase in the initial pressure of steam improves the thermal efficiency of steam power plant and also wetness fraction of such steam decreases at the end of expansion.

Which of the above statements are correct?

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

Sol: (*)



Fig. Effective of increase of pressure on Rankine cycle



Fig. Mean temperature of heat addition

121. A turbine develops 9000 kW when running at a speed of 150 r.p.m. and under a head of 30m. What is the specific speed of the turbine?

(a)	202 r.p.m	(b)	152 r.p.m
(c)	180 r n m	(d)	217 r n m

Sol: (a)

Specific speed of Turbine (N_s) = $\frac{N\sqrt{P}}{H^{5/4}}$

P = Power developed (kW)

$$H = Head(m)$$

$$N_{\rm s} = \frac{150 \times \sqrt{9000}}{(30)^{5/4}}$$

= 202.68 ≈ 202 rpm

- **122.** Consider the following statements regarding unit quantities:
 - 1. Unit specific speed is defined as the speed of a turbine working under unit head.
 - 2. Unit discharge is defined as the discharge passing through a turbine, which is working under a unit head.
 - 3. Unit power is defined as the power developed by a turbine working under unit speed.

Which of the above statement is/are correct?

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

Sol: (c)

• **Specific speed (N_s)**: Specific speed is defined as the speed of turbine which is identical in shape, geometrical dimensional, blade angles, gate openings etc.. with the actual turbine but of such a size that it will develop unit power when working under unit head.





SET - B

- Specific speed is used to compare two turbines of similar type i.e., when they are geometrically similar and when their velocity triangle is also similar (i.e., when the turbines are homologous)
- There is no such term like "unit specific speed" given in option 1 of the question. So, option (1) is incorrect.
- Unit discharge is defined as the discharge passing through a turbine, which is working under a unit head (i.e. 1 m). It is denoted by symbol 'Q_u'.
- Unit power is defined as power developed by a turbine, working under a unit heat (i.e. 1 m). It is denoted by symbol 'P_u.



- **123.** Consider the following statements regarding characteristic curves of hydraulic turbines:
 - Main characteristic curves are obtained by maintaining a constant speed and a constant gate opening on a turbine
 - 2. Operating characteristic curves are obtained by maintaining a constant head on a turbine
 - Constant efficiency curves are known as Muschel curves

Which of the above statements is/are correct ?

(c) 2 only (d) 3 only

Sol: (c)

- Characteristic curve of hydraulic turbine are the curves which help in studying the performance of the turbine over a wide range of operating conditions.
- These curves belonging to any turbine are supplied by its manufactures based on actual tests performed on the turbine under different working conditions.
- The characteristic curves are obtained are as follows.

- 1. Constant head curves or main characteristic curves
- 2. Constant speed curves or operating characteristic curves.
- 3. Constant efficiency curves or Muschel curves or Iso efficiency curve.
- 1. Constant Head curves or main characteristic curves.
 - Constant head curves are the main characteristics of a turbine.
 - These curved are obtained by maintaining head and gate opening constant. Then the speed of the turbine is varied by admitting different rates of flow.
 - So, option (1) is incorrect.
- 2. Constant Speed Curves or Operating Characteristic Curves
 - These curves are obtained when the speed of turbine is constant.
 - The tests are conducted by varying the discharge with the help of regulating the gate opening at constant speed.
 - The head may or may not remain constant.
 - However, in case of turbine the head is generally constant.
 - So, option (2) is correct.
- 3. Constant Efficiency Curves or Muschel Curves or Iso-Efficiency Curves
 - These curves are obtained from the sped vs. efficiency and speed vs. discharge curves for different gate openings.
- **124.** Consider the following statements regarding centrifugal pumps:
 - 1. The rotating part of a centrifugal pump is called runner.
 - 2. Volute casing is spiral type in which area of flow increases gradually.
 - 3. In vortex casing, a vortex chamber is introducing between the casing and impeller.



SET - B

4. Foot valve is fitted at the lower end of suction pipe.

Which of the above statements is/are correct ?

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

Sol: (b)

Main Parts of a Centrifugal Pump

The following are the main parts of a centrifugal pump :

- 1. Impeller
- 2. Casing
- 3. Suction pipe with a foot valve and a strainer
- 4. Delivery pipe



1. **Impeller.** The rotating part of a centrifugal pump is called 'impeller'. It consists of a series of backward curved vane.

Note: The rotating part of Turbine is called Runner.

2. Casing. The casing of a centrifugal pump is an airtight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the

impeller is converted into pressure energy before the water leaves the casing and enters the delivery pipe.

• The following three types of the casings are commonly adopted:

(a) Volute Casing.

- Volute casing surrounds the impeller.
- It is of spiral type in which area of flow increases gradually.
- The increase in area of flow decreases the velocity of flow. The decrease in velocity increases the pressure of the water flowing through the casing.
- It has been observed that in case of volute casing, the efficiency of the pump increases slightly as a large amount of energy is lost due to the formation of eddies in this type of casing.

(b) Vortex Casing.

- If a circular chamber is introduced between the casing and the impeller as the casing is known as Vortex Casing.
- By introducing the circular chamber, the loss of energy due to the formation of eddies is reduced to a considerable extent.
- Thus the efficiency of the pump is more than the efficiency when only volute casing is provided.

(c) Casing with Guide Blades.

- In this case, the impeller is surrounded by a series of guide blades mounted on a ring which is known as diffuse.
- The guide vanes are designed in such a way that the water from the impeller enters the guide vanes without shock.
- Also the area of the guide varies increases, thus reducing the velocity of flow through guide vanes and consequently increasing the pressure of water.



SET - B

- Guide Vanes Vortex chamber Impeller (a) Vortex Casing (b) Casing with Guide Blades
 - (d) Delivery Pipe.
 - A pipe whose one end is connected to the outlet of the pump and other end delivers the water at a required height is known as delivery pipe.
- 125. Consider the following statements:
 - The horizontal distance between the centre line of the pump and the water surface in the tank to which water is delivered is known as delivery head.
 - 2. The sum of suction head and delivery head is known as static head.
 - 3. The manometric head is defined as the head against which a centrifugal pump has to work.

Which of the above statements is/are correct ?

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

Sol: (b)

Definitions of Heads and Efficiencies of a Centrifugal pump :

 Suction Head (h_s): It is the vertical height of the centre line of the centrifugal pump above the water surface in the tank or pump from which water is to be lifted.

This height is also called suction lift and is denoted by 'h_s'

 Delivery Head (h_d) : The vertical distance between the centre line of the pump and the water surface in the tank to which water is delivered is known as delivery head.

This is denoted 'h_d'.

 Manometric Head (H_m) : The manometric head is defined as the head against which a centrifugal pump has to work.

It is denoted by 'H_m'.

$$H_{\rm m} = h_{\rm s} + h_{\rm d} + h_{\rm f} + h_{\rm fd} + \frac{V_{\rm d}^2}{2g}$$

where,

 $h_s =$ Suction head, $h_d =$ Delivery head

 h_f = Frictional head loss in suction pipe,

 h_{fd} = Frictional head loss in delivery pipe, and

 V_d = Velocity of water in delivery pipe.

- **126.** Consider the following statements regarding efficiencies of a centrifugal pumps :
 - 1. The ratio of the manometric head to the head imparted by the impeller to the water is known as manometric efficiency.
 - 2. The ratio of the power available at the impeller to the power at the shaft of the centrifugal pump is known as overall efficiency.
 - The ratio of the power output of the pump to the power input to the pump is known as mechanical efficiency.

Which of the above statements is/are correct ?

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

Sol: (c)

Manometric Efficiency (η_{mano}): It is the ratio of manometric head to the head imparted by the impeller to the water is known as Manometric efficiency.

$$\eta_{mano} = \frac{Manometric head(H_m)}{Head imparted by impeller to water}$$

$$= \frac{H_m}{\left(\frac{V_{w_2}u_2}{g}\right)} = \frac{gH_m}{V_{w_2}u_2}$$





SET - B

Mechanical Efficiency
$$(\eta_m)$$
: It is the ratio of power available at the impeller to the power available at shaft of centrifugal pump is known as mechanical efficiency.

 $\eta_m = \frac{Power at the impeller}{Power at the shaft}$

$$= \frac{\left(\frac{\text{Work done by impeller per second}}{100}\right)}{\text{Shaft power}}$$

$$= \frac{\frac{W}{g} \times \left(\frac{V_{w_2} u_2}{1000}\right)}{\text{Shaft power}}$$

Overall efficiency (η_0 **):** It is the ratio of power output of the pump to power input to the pump.

$$\eta_0 = \frac{\left(\frac{WH_m}{1000}\right)}{Shaft Power}$$

Also,

 $\eta_0 = \eta_{manometric} \times \eta_{mechanical}$

127. The outlet velocity of flow and outlet velocity of whirl of an impeller of a centrifugal pump are 5 m/s and 12 m/s respectively. What is the resultant velocity at outlet ?

	(a)	17	m/s		(b)	7	m/s	
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- (c) 11 m/s (d) 13 m/s
- Sol: (d)



Output velocity of flow (V_{fl}) = 5 m/s Velocity of whirl (V_{wl}) = 12 m/s

$$|V| = \sqrt{V_{f1}^2 + V_{w1}^2}$$

$$= \sqrt{5^2 + 12^2} = 13 \text{ m/s}$$

- **128.** Consider the following statements regarding steam nozzles :
 - 1. Nozzle efficiency is defined as the ratio of the actual enthalpy drop to the isentropic enthalpy drop between the same pressures.
 - 2. Velocity coefficient is defined as the ratio of the actual exit velocity to the exit velocity when the flow is isentropic between the same pressures.
 - 3. Velocity coefficient is the square root of nozzle efficiency.

Which of the above statements are correct ?

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

Sol: (d)

Nozzle efficiency is defined as the ratio of actual heat drop to that due to isentropic expansion. In another way, we can say that it is the ratio of actual gain in kinetic energy to that due to isentropic expansion i.e.,

$$\eta_{n} = \frac{(h_{1} - h'_{2})_{actual}}{(h_{1} - h_{2})_{isentropic}} = \frac{C_{2}^{'2} - C_{1}^{2}}{C_{2}^{2} - C_{2}^{2}}$$

If C_1 is small compared with C_2 , then nozzle efficiency is given by

$$\eta_n = \frac{C_2'^2}{C_2^2} = k_n^2$$

where, $K_n = \frac{C_2}{C_2}$ = velocity coefficient for the nozzle.

- **129.** Consider the following statements regarding steam turbines :
 - Blades efficiency is the ratio of the work done on the blade per second to the energy entering the blade per second.



SET - B

- 2. Internal efficiency is the ratio of the heat converted into useful work to the total adiabatic heat drop.
- 3. Net efficiency is the ratio of brake thermal efficiency to diagram thermal efficiency.

Which of the above statements are correct ?

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

Sol: (c)

Net efficiency or efficiency ratio

Break thermal efficiency

Thermal efficiency on the rankine cycle

130. Consider the following statements :

- 1. Bleeding is the process of draining steam from the turbine at certain point during its expansion.
- 2. There is a usual practice in bleeding installation to allow the bled steam to mix with the preheated air, after that the mixture of steam and air proceeds to the boiler.
- 3. The objective of governing is to keep the turbine speed fairly constant irrespective of load.

Which of the above statements are correct ?

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

Sol: (a)

There is usual practice is bleeding installation to allow bled steam is mix with feed water not preheated air. It is preheating of air done in air preheater.

131. The indicated work of a single-stage reciprocating air compressor is 250 kJ/min. What is the indicated power ?

(a)	250 kW	(b) 0.24 kW
(c)	15 kW	(d) 4.16 kW

Sol: (d)

$$i_p = \frac{250}{60} = 4.1667 \text{ kW}$$

- 132. Consider the following statements :
 - 1. Thermal efficiency is the ratio of the network output to the heat supplied.
 - Compressor isentropic efficiency is the ratio of the work output in isentropic compression to the ideal work required.
 - 3. Turbine isentropic efficiency is the ratio of the actual work output to the isentropic work output.

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

Sol: (c)

$$\eta_{t} = \frac{\text{Output}}{\text{Heat supplied}}$$
$$(\eta_{\text{isen}})_{\text{compressor}} = \frac{W_{\text{in}}}{W_{\text{req}}}$$
$$(m_{\text{output}})_{\text{output}}$$

$$(\Pi_{isen})_{turbine} = W_{required}$$

- **133.** Consider the following statements regarding modes of failure :
 - 1. A ductile material is one which has a relatively large tensile strain before fracture takes place.
 - 2. A brittle material has a relatively small tensile strain before fracture.
 - A static load is defined as a force, which is gradually applied to a mechanical component and which changes its magnitude or direction with respect to time.

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



SET - B

Sol: (d)

A ductile material is one having a relatively large tensile strain up to the point of rupture (for example, structural steel or aluminium) where a brittle material has a relatively small strain up to this same point.

For example cast iron and concrete.

A static load is defined as a force, which is gradually applied to a mechanical component and which changes its magnitude or direction with respect to time.

- **134.** Consider the following statements regarding theories of elastic failure :
 - Experimental investigations suggest that maximum principal stress theory gives good predictions for brittle materials.
 - 2. Maximum shear stress theory predicts that the yield strength in shear is equal to the yield strength in tension.
 - 3. Maximum shear stress theory is also known as Coulomb, Tresca and Guest theory.

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

Sol: (b)

- (a) Max shear stress theory \rightarrow most conservative.
- (b) Max distortion energy theorem → most appropriate for ductile material
- (c) Max principal stress theory → most appropriate for brittle material

According to maximum shear stress theory yield strength in shear is half the yield strength in tension.

Maximum shear stress theory is also known as Coulomb, Tresca and Guest theory.

135. Consider the following statements regarding distortion energy theory :

- 1. It is known a Huber-von Mises-Hencky theory.
- 2. The yield strength in shear is 0.577 times the yield strength in tension.
- 3. Experiments have shown that the distortion energy theory is in better agreement for predicting the failure of a brittle component than any other theory of failure.

Which of the above statements are correct ?

(a)	1 and	2 only	(b)	1	and	3	onlv
(9)	i unu	<u> </u>	(2)	•	unu	0	only

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

Sol: (a)

Max Shear Strain Energy Theory (Distortion Energy Theory) (Huber – Hencky – Von Mises Theory)

Max shear strain energy in a body should be less than or equal to max shear strain energy under uniaxial loading

$$\frac{1}{2} \Big[\left(\sigma_1 - \sigma_2 \right)^2 + \left(\sigma_2 - \sigma_3 \right)^2 + \left(\sigma_3 - \sigma_1 \right)^2 \Big] \leq f_y^2$$

$$\begin{array}{l} \text{for design} \frac{1}{2} \left[\left(\sigma_1 - \sigma_2 \right)^2 + \left(\sigma_2 - \sigma_3 \right)^2 + \left(\sigma_3 - \sigma_1 \right)^2 \right] \\ \\ \leq \left(\frac{f_y}{\text{F.o.s.}} \right)^2 \end{array}$$

This theory is applicable for ductile material.

For 2D case

$$\sigma_1^2 + \sigma_2^2 - \sigma_1 \sigma_2 \leq f_y^2$$

For pure shear $s_1 = t$, $s_2 = -t$

$$\Rightarrow 3t^2 \leq f_y^2$$

 $\tau \leq \frac{t_y}{\sqrt{3}}$ Hence this theory is in perfect agreement with the case of pure shear.

- **136.** Consider the following statements regarding cooling towers in thermal power plants :
 - 1. In a natural drought cooling tower, the cold water is allowed to fall over louvers.

MECHANICAL ENGINEERING



ESE 2024 Detailed Solution

SET - B

 $\frac{1}{4}$ $\frac{1}{0.074}$ $\frac{1}{2s}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{40}$ $\frac{1}{2s}$

Fig. The use of condenser increases the

specific work output of turbine from

 $(h_1 - h_3)$ to $(h_1 - h_2)$

- ${\scriptstyle \bullet}\, {\sf As}$ exhaust pressure \downarrow , net work output \uparrow
- \bullet Further by lowering the exhaust pressure will \uparrow the work output.

Condenser is used to reduce the turbine exhaust pressure so as to increase the specific output of the turbine. If the circulating cooling water temperature in a condenser is low enough (say 30°C), it creates a low back pressure (vacuum) for the turbine. This pressure is equal to the saturation pressure corresponding to the condensing steam temperature (say 0.074 bar at 40°C), which, in turn, is a function of the cooling water temperature.

A condenser by lowering the back pressure, say, from 1.013 to 0.074 bar, thus increases the steam flow for a given output. The lower the pressure, the greater the output and efficiency.

- **138.** Multi-cylinder turbines which have their rotors mounted on one and the same shaft and coupled to a single generator are known as
 - (a) single-shaft turbines
 - (b) multiaxial turbines
 - (c) topping turbines
 - (d) back pressure turbines

Sol: (a)

 In an atmospheric type cooling tower, the hot water from the condenser is pumped to the troughs adn nozzles situated near the bottom.

- In forced drought cooling towers, drought fans are installed at the bottom of towers.
- Mechanical drought cooling towers may be forced drought cooling towers or induced drought cooling towers.

Which of the above statements are correct ?

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

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

Sol: (c)

- In natural draught cooling tower the hot water is allowed to fall over louvers
- In atmospheric type cooling tower hot water from condenser is pumped to the troughs and nozzle situated at top.
- **137.** Consider the following statements regarding steam condensers :
 - 1. Power plant cycle improves in efficiency as the turbine exhaust pressure drops with steam condenser.
 - 2. The use of condenser decreases the size of boiler installation.
 - The vacuum obtainable in a condenser is governed by the inlet water temperature which in turn varies with the amount of condensing water used per kg of steam and its initial temperature.

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

Sol: (d)

MECHANICAL ENGINEERING



SET - B

Multi-cylinder turbines which have their rotors mounted on one and the same shaft and coupled to a single generator are known as single shaft turbine.

Turbine with separate rotor shafts for each cylinder placed parallel to each other are known as multiaxial turbine.

- **139.** Consider the following features for a gas turbine plant :
 - 1. Intercooling
 - 2. Regeneration

ESE

2024

Detailed Solution

3. Reheat

Which of the above features in a gas turbine cycle increase the specific output and thermal efficiency of the plant ?

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

Sol: (d)

For reheat cycle:



For intercooling cycle: Intercooling will help in \uparrow the net work output of the cycle. Because lower compressor outlet temperature the fuel flow rate to obtain a given turbine inlet temperature will \uparrow .

Regeneration cycle will ↑ the thermal efficiency but not change in specific output

Combined effect of all \uparrow workoutput & η

		Effect on	
S.No.	Addition to simple cycle	η	W/C _p T ₁
1.	Heatexchange	+50.0	No change
2.	Intercooling	-6.50	+10.2
3.	Rheat	-10.4	+24.5
4.	Reheat and heat exchange	+66.7	+24.5
5.	Intercooling and heat exchange	+68.0	+10.2
6.	Reheat and intercooling	-18.2	+34.7
7.	Reheat, intercooling and heat exchange	+80.2	+34.7



- **140.** Consider the following statements regarding combustion of fuels :
 - 1. Carbon combines with oxygen to form carbon monoxide.
 - 2. Hydrogen burns with oxygen to give water as the product.
 - When methane burns in the presence of oxygen, the combustion products are carbon dioxide and water vapours.

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

Sol: (d)

141. Consider the following statements :

- 1. Air contains 23% of oxygen and 77% of nitrogen by volume.
- 2. The main constituents of natural gas are methane and ethane.
- 3. Coal gas mainly consist of hydrogen, carbon monoxide and hydrocarbons.

Which of the above statements are correct ?

ESE 2024

MECHANICAL ENGINEERING



SET - B

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

Sol: (c)

Air contain 23% oxygen and 77% nitrogen by weight.

- **142.** Consider the following statements regarding properties of good coal :
 - 1. It should have low ash content and high calorific value.
 - 2. It should have large percentage of sulphur (more than 25%)
 - 3. It should have high grindability index.

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

Sol: (b)

A good coal should have:

- Low ash content and high calorific value
- Small percentage of sulphur (less than 1%)
- Good burning characteristics (i.e., should burn freely without agitation) so that combustion will be complete
- High grindability index (in case of ball mill grinding)
- High weatherability
- **143.** Which one of the following interpersonal roles the manager is expected to train, counsel, mentor and encourage for high employee performance ?
 - (a) Figurehead role (b) Leader role
 - (c) Liaison role (d) Monitor role

Sol: (b)

The leader responsible for the work of subordinate, motivating and encouraging employees, exercising their formal authority.

- **144.** Which one of the following approaches includes application of statistics, optimization models, information models and computer simulations ?
 - (a) Quantitative approach
 - (b) Qualitative approach
 - (c) Contingency approach
 - (d) Behavioral approach

Sol: (a)

The quantitative approach to management involves the use of quantitative techniques, such as statistics, information models and computer simulations to improve decision makings.

- **145.** Consider the following statements regarding purpose of the micromotion study :
 - 1. It is to study the nature and path of movements for accomplishing the elements of an operation.
 - It is to impact training to the operators regarding motion economy principles so that unnecessary motion or movement by the operators be avoided.
 - 3. It is to find the most efficient way of accomplishing the elements.

Which of the above statements is/are correct ?

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

Sol: (d)

The following are the purposes of micromotion study:

- 1. To study the nature and path of movements for accomplishing the elements of an operation.
- 2. To find the most efficient way of accomplishing the elements
- 3. To impact training to the operators regarding motion economy principles so that unnecessary motion or movement by the operator may be avoided.

ESE MECHA 2024



SET - B

- Detailed Solution
 - 4. To keep a permanent record of the most efficient way of doing a task for new reference.
 - 5. To collect motion time data (MTD) for calculating synthetic time standard for different elements.
 - **146.** Consider the following statements regarding computer-aided manufacturing :
 - 1. Inventory control is concerned with managing and controlling the physical operations in the factory.
 - 2. Manufacturing control is concerned with the demand fulfillment and also to reduce the inventory to eliminate the wastage and extra money investment.
 - Shop floor control is concerned with the problem of monitoring the progress of processing, assembling, and inspection of the products in the factory.

Which of the above statements is/are correct ?

- (a) 1 and 2 only (b) 1 and 3 only
- (c) 3 only (d) 1, 2 and 3
- Sol: (c)
- **147.** Which of the following is/are not included in flexible manufacturing system workstation facilities ?
 - (a) Machining centres
 - (b) Milling modules
 - (c) Inspection stations
 - (d) Welding workspace

Sol: (d)

FMS workstation include following equipments/ station

- Machine centre,
- Milling and turning units
- Sheet metal section
- Assembly workstation
- Inspection stations

There may be welding workstation and forging workstation to automate welding and forging processes.

So, answer should be welding workplace.

- **148.** Consider the following statements regarding pure project :
 - 1. The project manager has full authority over the project.
 - 2. Team members report to one boss.
 - 3. It has longest communication chains.

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

Sol: (a)

In pure project organization structure, the lines of communication are shorter than the multi-disciplined functional route.

- **149.** Consider the following statements regarding costs associated with a project :
 - 1. Direct costs increase with time.
 - 2. Direct costs are normal costs that can be assigned directly to a specific work package or project activity.
 - 3. Crashing activities increase direct costs.

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
- Sol: (c)

Direct cost always varies as inverse proportion with time.

- **150.** Consider the following statements regarding redundancy :
 - 1. Warm redundancy is also known as hot redundancy.



SET - B

- Sol: (b)
 - · Warm redundancy is also known as lightly loaded redundancy.
 - Active redundancy is also known as parallel or hot redundancy.
 - Passive redundancy is also known as standby or cold or unloaded redundancy.
- 2. Active redundancy is also known as lightly loaded redundancy.
- 3. Passive redundancy is also known as standby redundancy.

Which of the above statements is/are correct ?

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