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ESE - 2026

Preliminary Examination

QUESTIONS WITH DETAILED SOLUTIONS

MECHANICAL ENGINEERING

(SET-D)

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MECHANICAL ENGINEERING [SET - D]

SUBJECTWISE WEIGHTAGE

S.No.	Name of the Subject	No. of Questions
01	Fluid Mechanics & Turbo-machinery	21
02	Heat Transfer	7
03	Machine Design	13
04	Strength of Materials	9
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15	Mechatronics and Robotics	11
16	Maintenance Engineering	2
Total No. Of Questions		**150**

01. Which one of the following does not promote knocking in SI engines?
(a) High compression ratio
(b) Poor cylinder cooling
(c) Optimum mixture strength
(d) Retarded ignition timing

01. Ans: (c)

Sol: High compression ratio, poor cylinder cooling and retarded ignition timing can promote the knocking tendency in SI engine. Optimum mixture strength obstruct the knocking of SI engine.

02. In SI engines, the Performance Number (PN) is a useful measure of:
(a) Thermal Efficiency
(b) Mechanical Efficiency
(c) Indicated Power
(d) Detonation Tendency

02. Ans: (c)

Sol: For SI engines, the Performance Number (PN) is a useful measure of indicated power.

03. The Performance Number (PN) of an SI engine is obtained on a specified engine under specified set of conditions by varying the:
(a) Inlet Pressure
(b) Inlet Temperature
(c) Compression Ratio
(d) Valve Timing

03. Ans: (c)

Sol: Performance Number (PN) of an SI engine is determined by comparing the knocking performance of a test fuel with reference fuels on a standard engine. It is obtained by varying the compression ratio until a standard knock intensity is reached.

04. Which one of the following is not an assumption of the standard vapour compression cycle?
(a) Compression is isentropic.
(b) Heat rejection is isentropic.
(c) Saturated liquid at condenser exit.
(d) Heat absorption is by evaporation and is isobaric.

04. Ans: (b)

Sol: Heat rejection in VCR cycle takes place isobarically (theoritically).

05. R22 refrigerant is compressed in a centrifugal compressor from 3 bar to 12 bar. The small stage efficiency is 80%. Assume that the small stage efficiency and isentropic efficiency of the compressor are same. The isentropic index of vapour is 1.10. What is the polytropic index of the vapour?
(a) 0 (b) 0.12
(c) 1 (d) 1.12

05. Ans: (d)

Sol:

$$\eta_{poly} = \frac{\gamma - 1}{\gamma} \times \frac{n}{n-1}$$

$$0.8 = \frac{1.1 - 1}{1.1} \times \frac{n}{n-1}$$

$$\Rightarrow n = 1.128$$

06. In case of azeotropes, from the performance point of view, it is desirable to have refrigerant mixtures with zero temperature glide so that:
(a) Dew point temperatures = Bubble point temperatures

(b) Dew point temperatures > Bubble point temperatures
(c) Dew point temperatures < Bubble point temperatures
(d) Dew point temperatures = Bubble point Temperatures = 100°C

06. Ans: (a)

Sol: Bubble point temperature is the temperature at which a liquid mixture, at a specific pressure, begins to form its first bubble of vapor upon heating, signifying the onset of vaporization, but for mixture, it depends on composition.
Azeotrope is a mixture of two or more Halocarbons.
Azeotropes are kept in 500 series,
dew point temperature = Bubble point (it is called zero temperature glide).

07. In a vapour absorption refrigeration system, which one of the following statements is correct regarding the effect of aqua-ammonia mixture instead of pure ammonia entering the evaporator?
(a) Evaporator temperature remains constant.
(b) Refrigeration effect is increased.
(c) Coefficient of performance is decreased.
(d) Condenser temperature remains constant.

07. Ans: (c)

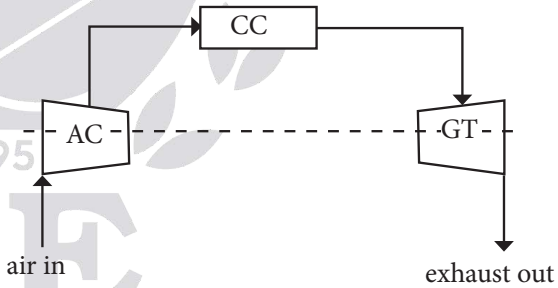
Sol: If aqua-ammonia (Ammonia vapor + water vapor mixture) is allowed to condenser, the COP of system decreases, since the water vapor may freeze in the expansion process. (Analyzer and Rectifier are used for removing the water vapor present in the aqua-ammonia).

08. Consider the following statements regarding gas turbine plant:
1. If the gas turbine plant is used as an aircraft engine, the net output at the turbine shaft is used to drive a propeller in a turbo-prop engine.
2. In simple open circuit gas turbine plants, the hot gases from the combustion chamber pass out to the atmosphere after expanding through the turbine.
3. In closed circuit gas turbine plants, the same working fluid circulates through its various components.

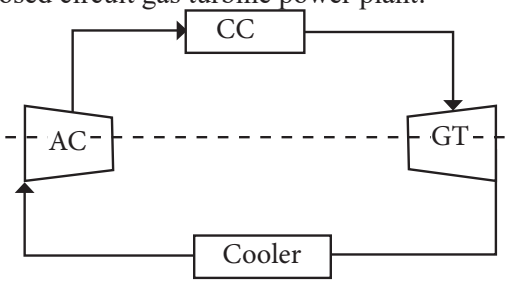
Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

08. Ans: (d)

Sol: All the 3 statements given are correct.
Open circuit gas turbine power plant:



Closed circuit gas turbine power plant:



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ENGINEERING MATHEMATICS	20 Questions
NUMERICAL ABILITY	20 Questions
VERBAL ABILITY	10 Questions

- No. of Questions: 50
- Total Marks: 75
- Duration: 90 Minutes
- Mode: Online

09. Consider the following statements regarding impellers of the centrifugal pump:
1. Shrouded impellers are good for handling concrete.
2. Semi-enclosed impeller is used, when the liquid to be pumped contains some solids in suspension.
3. The open impeller is used to handle highly solid-laden liquids like slurry.

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

09. Ans: (c)

Sol: The impellers may be classified as (a) closed or shrouded impeller, (b) semi-open impeller; and (c) open impeller.
A closed or shrouded impeller is that whose vanes are provided with metal cover plates or shrouds on both sides. These plates or shrouds are known as crown plate and lower or base plate. The closed impeller provides better guidance for the liquid and is more efficient. However, this type of impeller is most suited when the liquid to be pumped is pure and comparatively free from debris.

10. The water jet in a Pelton wheel has a velocity of 93 m/s. The rotational speed of the wheel is 600 rpm. The ratio of bucket velocity to jet velocity is 0.47. What is the diameter of the wheel?
(a) 4.914 m
(b) 1.391 m
(c) 2.162 m
(d) 4.527 m

10. Ans: (b)

Sol: Given: V = 93 m/s, N = 600 rpm, $\phi = 0.47$

$$U = \frac{\pi DN}{60}$$

$$\phi = U/V$$

$$\phi = \frac{\pi DN}{60\ V}$$

$$0.47 = \frac{\pi \times D \times 600}{60 \times 93}$$

$$\therefore \quad D = 1.391$$

11. A Pelton turbine has hydraulic efficiency 87.7% and coefficient of velocity 0.97. What is the wheel efficiency of the turbine?
(a) 93.2% (b) 84.1%
(c) 87.4% (d) 98.1%

11. Ans: (a)

Sol: Given: $\eta_h = 0.877$, $C_v = 0.97$
For a Pelton turbine,

$$\eta_h = \eta_w C_v^2$$

$$\eta_w = \frac{\eta_h}{C_v^2} = \frac{0.877}{(0.97)^2} \approx 0.933$$

$$\eta_w = 93.2\ \%$$

12. Which one of the following is defined as the ratio of reaction effect (energy transfer by static pressure) to the total energy transfer in the rotor?
(a) Degree of freedom
(b) Degree of impulse
(c) Effective power
(d) Degree of reaction

12. Ans: (d)

Sol: Degree of reaction is defined as the ratio of pressure drop in the runner to the hydraulic work done on the runner. The term degree of reaction is a measure of the extent to which the rotor itself contributes to the increase in the static head of fluid.

13. A Francis turbine has hydraulic efficiency 95% and mechanical efficiency 80%. What is the overall efficiency?
(a) 76.0% (b) 87.6%
(c) 98.7% (d) 85.4%

13. Ans: (a)

Sol: Given:
Hydraulic efficiency = 95%
Mechanical efficiency = 80%
Overall efficiency
= Hydraulic efficiency × Mechanical efficiency
Overall efficiency = 0.95 × 0.80 = 76%

14. In a Kaplan turbine, the number of blades varies from:
(a) 10 to 24 (b) 3 to 8
(c) 10 to 15 (d) 15 to 24

14. Ans: (b)

Sol: A Kaplan turbine generally has 3 to 8 blades, most commonly 4 to 6. The number depends on turbine size, head, and flow rate. Fewer blades reduce drag, while more blades improve torque, structural strength, and performance under varying load conditions.

15. A reciprocating pump which is used to pump water has a bore of 120 mm and a stroke of 220 mm. It runs at a speed of 40 rpm. The delivery pipe is 80 mm in diameter and 30 m in length. What is the acceleration head without the air vessel?
(a) 20.45 m (b) 15.98 m
(c) 10.34 m (d) 13.26 m

15. Ans: (d)

Sol: Given:
D = 120 mm, r = 220/2 = 110 mm,
N = 40 rpm, d = 80 mm, L = 30
Acceleration head $= \frac{L}{g}\frac{A}{a}\omega^2 r$

$$= \frac{30}{9.81}\frac{\frac{\pi}{4}\times(0.12)^2}{\frac{\pi}{4}\times(0.08)^2}\left(\frac{2\pi\times 40}{60}\right)^2\times 0.11$$

= 13.26 m

16. The correct expression for air standard efficiency of the Otto Cycle with compression ratio r is:
(a) $\eta_{Otto} = 1-\left[\frac{\gamma-1}{(r)^{\gamma-1}}\right]$
(b) $\eta_{Otto} = 1-\left[\frac{1}{(r)^{1-\gamma}}\right]$
(c) $\eta_{Otto} = 1-\left[\frac{1}{(r)^{\frac{\gamma-1}{\gamma}}}\right]$
(d) $\eta_{Otto} = 1-\left[\frac{1}{(r)^{\gamma-1}}\right]$

16. Ans: (d)

Sol: $\eta_{Otto} = 1-\frac{1}{(r)^{\gamma-1}}$
where, r = Compression ratio

17. Which one of the following models assumes that each mixture component behaves as an ideal gas as if it existed separately at the pressure p and temperature T of the mixture?
(a) Dalton's Model
(b) Kay's Model
(c) Amagat's Model
(d) Newton's Model

17. Ans: (c)

Sol: Amagat's Model (also known as the Law of Partial Volumes) assumes that each component in a gas mixture behaves as an ideal gas as if it existed separately at the total pressure (P) and temperature (T) of the entire mixture.

According to this model, the total volume of the mixture is the sum of these "partial volumes"

$$V = \sum V_i$$

18. With increase in pressure ratio, the isentropic efficiency of a compressor and a turbine:
(a) Increases for both
(b) Decreases for both
(c) Increases for turbine and decreases for compressor
(d) Decreases for turbine and increases for compressor

18. Ans: (d)

Sol: With increase in pressure ratio, compressor efficiency decreases, but turbine efficiency increases.

19. At the surface of an electric heater, the heat flux q is 5000 W/m^2. The heater temperature is 130°C, when it is cooled by air at 50°C. What is the heater temperature if the power is reduced so that q is 2500 W/m^2?
(a) $T_{heater} = 60°C$
(b) $T_{heater} = 70°C$
(c) $T_{heater} = 80°C$
(d) $T_{heater} = 90°C$

19. Ans: (d)

Sol: $q_1 = 5000\ W/m^2 = h(t_{heater_1} - t_{air})$

$5000 = h(130 - 50)$

$h = \frac{5000}{80}$

$q_2 = (t_{heater_2} - t_{air})$

$2500 = \frac{5000}{80}(t_{heater_2} - 50)$

$\Rightarrow 40 = t_{heater_2} - 50$

$\Rightarrow t_{heater_2} = 90°C$

20. For real bodies, the Emittance (ε) and Monochromatic Emittance (ε_λ) are:
(a) $\varepsilon = 1,\ \varepsilon_\lambda = 0$
(b) $\varepsilon = \varepsilon_\lambda = 0$
(c) $0 < \varepsilon < 1$ and $0 < \varepsilon_\lambda < 1$
(d) $\varepsilon = 0,\ \varepsilon_\lambda = 1$

20. Ans: (c)

Sol: For real bodies, emittance is always less than that of a black body and greater than zero. Hence both total emittance (ε) and monochromatic emittance (ε_λ) lie between 0 and 1.

21. Which one of the following represents the laminar flow with respect to Rayleigh Number (Ra)?
(a) Ra = 1
(b) $10^2 < Ra < 10^4$
(c) $10^4 < Ra < 10^9$
(d) $10^9 < Ra < 10^{16}$

21. Ans: (c)

Sol: Laminar flow → $10^4 < Ra < 10^9$

Turbulent flow → $Ra > 10^9$

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22. A wire is submerged horizontally in water at 5 bar with a saturation temperature of 150°C. The wire length is 250 mm and diameter is 2 mm. The wire carries a current of 100 A with an applied voltage of 2.5 V. If the surface of the wire is maintained at 200°C, what is the boiling heat transfer coefficient?

(a) $h = \frac{100}{\pi} W/m^2 °C$

(b) $h = \frac{1000}{\pi} W/m^2 °C$

(c) $h = \frac{10000}{\pi} W/m^2 °C$

(d) $h = \frac{100000}{\pi} W/m^2 °C$

22. Ans: (c)

Sol: $Q = h A \Delta T$

$\Rightarrow VI = h A \Delta T$

$h = \frac{VI}{A\Delta t} = \frac{2.5 \times 100}{\pi \times 0.002 \times 0.25 \times (200 - 150)}$

$h = \frac{10000}{\pi} W/m^2 °C$

23. Fouling inside the pipes of a heat exchanger increases with which one of the following fluid properties?

(a) Decrease in temperature and increase in velocity

(b) Increase in temperature and decrease in velocity

(c) Is independent of temperature and increase in velocity

(d) Decrease of temperature and is independent of velocity

23. Ans: (b)

Sol: Fouling increases with increase in temperature and decrease in velocity.

With higher velocity deposits are washed away.

24. A pyramid is having a square base and isosceles triangle side surfaces. What are the view factors (F) from the base of the pyramid? Consider pyramid base as surface 1 and remaining side faces as 2, 3, 4 and 5. (F_{ij} represents view factor of surfaces i and j).

(a) $F_{12} = F_{13} = F_{14} = F_{15} = 0$

(b) $F_{12} = F_{13} = F_{14} = F_{15} = 0.15$

(c) $F_{12} = F_{13} = F_{14} = F_{15} = 0.2$

(d) $F_{12} = F_{13} = F_{14} = F_{15} = 0.25$

24. Ans: (d)

Sol: $F_{11} + F_{12} + F_{13} + F_{14} + F_{15} = 1$

$F_{11} = 0$ (Flat surface)

$F_{12} = F_{13} = F_{14} = F_{15}$ (Symmetric)

$F_{12} = F_{13} = F_{14} = F_{15} = 0.25$

25. A thermal contact conductance of 10000 W/m^2 °C was measured at the interface of 1 cm thick aluminium plates with a thermal conductivity of 237 W/m°C at room temperature. What is the thickness of aluminium plate whose thermal resistance is equal to the thermal resistance of the interface between the plates?

(a) 1.185 cm (b) 2.37 cm

(c) 3.55 cm (d) 4.74 cm

25. Ans: (b)

Sol: $R_{th_{cont}} = \frac{L}{K} = \frac{1}{h}$

$\Rightarrow \frac{L}{K} = \frac{1}{h}$

$\Rightarrow L = \frac{K}{h} = \frac{237}{10000}$

$= 0.0237$ m

$= 2.37$ cm

26. The engine in which the combination of three opposed piston engines with three crankshafts interlinked to one another is called:
(a) 'X'-type engine
(b) 'H'-type engine
(c) 'U'-type engine
(d) Delta-type engine

26. Ans: (d)

Sol: Delta type engines are high performance two-stroke diesel engines with cylinders arranged in a triangle configuration, featuring opposed pistons and 3 crankshafts.

27. An engine with 50 kW power has a mechanical efficiency of 75%. If the frictional power is assumed to be constant with load, what is the mechanical efficiency at 50% of the load?
(a) 50% (b) 55%
(c) 60% (d) 65%

27. Ans: (c)

Sol: For full load (50 kW)

$$\eta_m = \frac{BP}{IP} = \frac{BP}{BP + FP}$$

$$0.75 = \frac{50}{50 + FP} \Rightarrow FP = 16.67 \text{ kW}$$

For 50% load (25 kW)

$$\Rightarrow \eta_m' = \frac{25}{25 + 16.67} \times 100 = 60\%$$

28. Which of the following sources contribute(s) majorly for the formation of Hydrocarbon emissions in Spark Ignition engines?
(a) Crevices
(b) Liquid fuel
(c) Exhaust valve leakage
(d) Deposits

28. Ans: (a)

Sol: Crevices in IC engines are narrow, high surface-to-volume ratio volumes within the combustion chamber. (Primarily between the piston top land and cylinder liner, where flame propagation is quenched).

29. Indicated specific fuel consumption of a four-stroke SI engine improves at a faster rate with increasing compression ratio than the brake specific fuel consumption, because both friction and heat losses:
(a) are decreasing with compression ratio
(b) are increasing with compression ratio
(c) are unaffected by compression ratio
(d) increase with cutoff ratio

29. Ans: (b)

Sol: Both friction losses and heat losses are increasing with increasing compression ratio.

30. The advancement of peak cylinder pressures ahead of Top Dead Centre (TDC) in an SI engine due to pre-ignition results in:
(a) Negative Work
(b) Positive Work
(c) Improved Combustion
(d) Increase in Mechanical Efficiency

30. Ans: (a)

Sol: Due to pre-ignition, the pressure acts on the piston increases in the last part of compression stroke.
For overcoming this additional pressure the piston demands more power, this extra power required for the piston to travel against additional pressure due to pre-ignition is called negative work.

31. Consider the following statements regarding pumps and compressors:
    1. High pressure multi-stage centrifugal pumps and compressors are widely used in petro-chemical industries.
    2. Industrial furnaces employ fans and blowers of various sizes for producing the required draught.
    3. Small gas turbines are used to drive turbo pumps and generators in underwater vehicles.

    Which of the above statements are correct?
    (a) 2 and 3 only (b) 1 and 3 only
    (c) 1 and 2 only (d) 1, 2 and 3

31. Ans: (d)
Sol: All the 3 given statements are correct.

32. Consider the following statements regarding propulsive devices:
    1. Thermal efficiency of an engine is defined as the ratio of useful work done by the thrust to energy supplied to the engine.
    2. Propulsive efficiency is defined as the ratio of useful work done by the thrust to kinetic energy available for propulsion.
    3. The overall efficiency of a propulsive device is defined as the ratio of useful work done by the thrust to energy supplied to the engine.

    Which of the above statements are correct?
    (a) 1 and 2 only (b) 1 and 3 only
    (c) 2 and 3 only (d) 1, 2 and 3

32. Ans: (b)
Sol: The ratio between thrust power and propulsive power is called propulsive efficiency.
First statement and third statements are correct.

33. Consider the following statements regarding ramjet engines:
    1. In ramjet engine, the pressure rise in the engine is wholly due to the pulse effect.
    2. On account of the absence of the turbine and compressor in ramjet engines, high temperature in the order of 2000°C can be employed in the combustion chamber.
    3. Ramjet engine is ideal for propulsion of hypersonic aircraft.

    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

33. Ans: (c)
Sol: In ramjet engine pressure increases by converging-diverging diffuser (not by pulse effect).
Second statement and third statement are correct.

34. Consider the following statements regarding pulse jet engines:
    1. Pulse jet engine is a thrust-producing device without turbine and compressor.
    2. In the combustion chamber of pulse jet engines, the fuel-rich mixture is exploded by spark plug.
    3. The frequency of explosions in pulse jet engines is as high as 10 per second.

    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

34. Ans: (d)
Sol: All the 3 statements are correct.

35. Consider the following statements regarding compressors:
    1. A centrifugal compressor like a pump is a head or pressure producing device.
    2. Performance-wise, centrifugal compressor is less efficient (3 - 5%) than axial type.
    3. Centrifugal type of compressor is suitable for high specific speed, low pressure ratio and high mass flow application.

    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

35. Ans: (d)

Sol: Compressor is for boosting pressure of compressible fluid like air.

Pump is for boosting pressure of incompressible fluid like water.

Since the pressure rise per stage of axial flow compressor is low, it maintains better efficiency than centrifugal compressor. Centrifugal compressor is a high speed machine to have the large mass flow rates.

36. Consider the following statements regarding condensers:
    1. Vacuum efficiency is defined as the ratio of the maximum obtainable vacuum to the actual vacuum.
    2. Condenser efficiency is defined as the ratio of the difference between the outlet and inlet temperatures of cooling water to the difference between the temperature corresponding to the vacuum in the condenser and inlet temperature of cooling water.
    3. The deaeration of feed water helps both in maintaining better vacuum in the condenser and controlling corrosion of the steel shell and piping of the steam power plant.

    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

36. Ans: (c)

Sol: The ratio between actual vacuum and maximum possible vacuum in the condenser is called vacuum efficiency.

$$\therefore \eta_{vac} = \frac{\text{Vacuum in the condenser with air present}}{\text{Vacuum in the condenser without air present}}$$

Statement 1 is wrong.

37. Consider the following statements regarding the improvement of the Rankine cycle efficiency:
    1. Lowering the condenser pressure raises the thermal efficiency of the cycle.
    2. Raising the boiler pressure and temperature raises the thermal efficiency of the cycle.
    3. Raising steam temperature (superheating) raises the thermal efficiency of the cycle.

    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

37. Ans: (d)

Sol: All the 3 statements given are correct.

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38. Consider the following statements regarding regenerative cycle:
1. Reheating has limited ability to improve the thermodynamic efficiency of the cycle but it is quite useful in the reduction of moisture in the turbine.
2. It is observed that the largest single loss of energy in a power plant occurs at the condenser in which heat is rejected to the coolant.
3. Reducing the rejected heat drastically improves cycle efficiency.

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

38. Ans: (d)
Sol: All the 3 statements given are correct.

39. A steam power plant works on:
(a) Rankine cycle
(b) Diesel cycle
(c) Otto cycle
(d) Gas turbine cycle

39. Ans: (a)
Sol: Thermal power plants are constructed to work on Rankine cycle.

40. Which one of the following is **not** a primary fuel?
(a) Lignite
(b) Peat
(c) Petroleum
(d) Diesel

40. Ans: (d)
Sol: Primary fuels occur naturally and are used with little or no processing (e.g., peat, lignite, petroleum). Secondary fuels are derived from primary fuels after processing or refining.
Lignite — primary fuel
Peat — primary fuel
Petroleum — primary fuel
Diesel — derived from petroleum by refining (secondary fuel).

41. Match the following lists for different types of calorimeters which are used to determine the calorific value of fuels:

List - I
P. Solid and liquid fuels
Q. Only solid fuels
R. Only gaseous fuels

List - II
1. Bomb calorimeter
2. Lewis Thompson calorimeter
3. Junker's calorimeter

Select the correct answer using the code given below:

	P	Q	R		P	Q	R
(a)	2	1	3	(b)	1	2	3
(c)	2	3	1	(d)	3	1	2

41. Ans: (b)
Sol: Bomb calorimeter for measuring HCV of both solid and liquid fuels. Junker's gas calorimeter is for finding the HCV of gaseous fuels.

42. If the boilers are designed to operate above the critical pressure, then those are known as:
(a) Once-through boilers
(b) Drum boilers
(c) Forced circulation boilers
(d) Natural circulation boilers

42. Ans: (a)

Sol: Super critical boilers are called as drumless boilers or once through boilers. Ex: Benson boiler

43. Which one of the following is the method of reducing turbine blade speed for a given overall pressure drop?
(a) Compounding
(b) Momentum
(c) Curtis
(d) Impulsion

43. Ans: (a)

Sol: The method of reducing the speed of the turbine by expanding the steam in more than one stage is called compounding.

44. In which of the following types of condensers does exhaust steam coming from the turbine mix directly with the circulating cooling water?
(a) Jet condensers
(b) Non-mixing-type condensers
(c) Surface condensers
(d) Central flow condensers

44. Ans: (a)

Sol: In jet condenser both spent steam and cooling water are directly mixing.

45. Consider the following statements regarding cooling towers:
1. Cooling tower is a wooden or metallic rectangular structure, with packed baffling devices.
2. The hot water is delivered to the top of the tower and falls down through the tower and is broken into small particles while passing over the baffling devices.
3. The hot water falls down into a tank below the tower from where it can again be circulated to the compressor.

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

45. Ans: (c)

Sol: Cooling towers are generally made with hyperbolic geometry (not rectangular). Statement 1 is wrong.

46. Which one of the following statements is correct regarding the traction vector on any surface within a general fluid element in motion?
(a) The traction vector consists of only one contribution related to pressure.
(b) The traction vector has two separate contributions: pressure and gravitational force.
(c) The traction vector has two separate contributions: pressure and deformation-related forces.
(d) The traction vector is solely determined by the velocity of the fluid element.

46. Ans: (c)

Sol: The traction vector on a surface within a moving fluid element represents the stress acting on that surface. In a general fluid, stress has two components:

- Normal stress due to pressure
- Shear (viscous) stress due to deformation/ velocity gradients

Gravitational force is a body force, not part of the traction vector.

47. What does specific gravity of liquids represent?
(a) It is the ratio of density of a liquid at actual conditions to the density of pure water at 101 kN/m^3 and at 4°C.
(b) It is the ratio of density of a liquid at actual conditions to the density of pure water at 25°C.
(c) It is the ratio of density of pure water at 25°C to the density of liquid at actual conditions.
(d) It is the ratio of density of pure water to the density of liquid.

47. Ans: (a)

Sol: For liquids, it is the ratio of density of a liquid at actual conditions to the density of pure water at 101 kN/m^3 and at 4°C. The specific gravity of a gas is the ratio of its density to that of either hydrogen or air at some specified temperature or pressure. However, there is no general standard, so the conditions must be stated while referring to the specific gravity of a gas.

48. A cylinder of 0.12 m radius rotates concentrically inside a fixed hollow cylinder of 0.13 m radius. Both the cylinders are 0.3 m long. What is the viscosity of the liquid which fills the space between the cylinders, if a torque of 0.88 Nm is required to maintain an angular velocity of 2π rad/s?
(a) 0.597 Pa.s (b) 1.397 Pa.s
(c) 1.597 Pa.s (d) 0.397 Pa.s

48. Ans: (*)

Sol: $T = F\,r$

$T = \tau A\,r$

$= \mu \frac{du}{dy} A\,r$

$T = \mu\left(\frac{r\omega}{R-r}\right)2\pi r\,L\,r$

$\Rightarrow \mu = \frac{T(R-r)}{2\pi\omega\, r^3 L}$

$= \frac{0.88 \times 0.01}{2\pi(2\pi) \times 0.12^3 \times 0.3}$

$\Rightarrow \mu = 0.43$ Pa

49. Consider the following statements regarding pressure measurement:
1. Pressure is usually expressed with reference to absolute zero pressure.
2. Absolute pressure is the pressure expressed as a difference between its value and the absolute zero pressure.
3. When a pressure is expressed as a difference between its value and the local atmospheric pressure, it is known as gauge pressure.

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

49. Ans: (d)

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The unit of pressure is N/m^2 and is known as Pascal. Pressure is usually expressed with reference to either absolute zero pressure (a complete vacuum) or local atmospheric pressure. Absolute pressure is the pressure expressed as a difference between its value and the absolute zero pressure. When a pressure is expressed as a difference between its value and the local atmospheric pressure, it is known as gauge pressure.

Therefore, $p_{abs} = p - 0 = p$

$p_{gauge} = p - p_{atm}$

50. Consider the following statements regarding thermal stratification and Coriolis forces:
    1. Thermal stratification refers to the layering of fluid elements that occur due to the density gradient created by changes in temperature.
    2. Thermally stratified layers can make the flow irrotational from rotational.
    3. An originally irrotational flow may become rotational due to the presence of Coriolis forces.

    Which of the above statements is/are correct?
    (a) 1 only
    (b) 1 and 2 only
    (c) 1 and 3 only
    (d) 1, 2 and 3

50. Ans: (c)

Sol: Thermal stratification generally stabilizes the fluid and reduces vertical mixing. It does not convert rotational flow into irrotational flow. Hence, this statement is incorrect.

51. Consider the following statements regarding flowmeters :
    1. A venturi-meter is less accurate than an orifice-meter.
    2. An orifice-meter is a thin circular plate with a sharp-edged concentric circular hole in it.
    3. The stagnation pressure at a point in a fluid flow is the pressure which could result if the fluid were brought to rest isentropically.

    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

51. Ans: (c)

Sol: A venturi meter is generally more accurate than an orifice meter because it has lower energy loss and better pressure recovery.

Hence, statement 1 is incorrect.

52. Consider the following statements regarding dynamics of inviscid flows :
    1. Euler's equation of motion describes the dynamics of inviscid flows.
    2. Flows having only tangential velocities with streamlines as concentric circles are known as plane circular vortex flows.
    3. A free vortex flow is a rotational vortex flow where the tangential velocity is directly proportional to the radius of curvature.

    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

52. Ans: (b)

Sol: Flows having only tangential velocities with streamlines as concentric circles are known as plane circular vortex flows. A free vortex flow is an irrotational vortex flow where the total mechanical energy of the fluid elements remains same in the entire flow field and the tangential velocity is inversely proportional to the radius of curvature. A forced vortex flow is a rotational vortex flow where the tangential velocity is directly proportional to the radius of curvature. Pressure in vortex flows increases with an increase in radius of curvature. Spiral vortex flows are obtained as a result of superimposition of a plane circular vortex flow with a purely radial flow.

53. Consider the following statements regarding turbulent flow :
    1. The most important characteristic of turbulent motion is the fact that velocity and pressure at a point fluctuate with time in a random manner.
    2. Turbulence generated and continuously affected by fixed walls is designated as free turbulence.
    3. Turbulence generated by two adjacent layers of fluid in the absence of walls is termed as wall turbulence.

    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

53. Ans: (a)

Sol:

- In turbulent flow, velocity and pressure at a point fluctuate randomly with time.
- Turbulence influenced by fixed walls is called wall turbulence, not free turbulence.
- Turbulence generated between fluid layers without wall influence is termed free turbulence, not wall turbulence.

54. Consider the following statements regarding laminar-turbulent transition:
    1. The turbulent boundary layer continues to grow in thickness, with a small region below it, called a viscous sublayer.
    2. In viscous sublayer, the flow is well behaved, just as the turbulent boundary layer.
    3. The possibility of instability in boundary layer was felt by Prandtl.

    Which of the above statements is/are correct?
    (a) 1 only
    (b) 1 and 3 only
    (c) 2 and 3 only
    (d) 1, 2 and 3

54. Ans: (b)

Sol:

- In a turbulent boundary layer, the layer thickness increases downstream and a thin viscous (laminar) sublayer exists near the wall — correct.
- In the viscous sublayer, the flow is orderly and laminar, not turbulent; hence it is not "just like the turbulent boundary layer" — incorrect.
- The concept of boundary layer and its instability leading to transition was introduced by Prandtl — correct.

55. Consider the following statements regarding correlation functions:
1. Correlation studies reveal that the turbulent motion is composed of eddies which are convected by the mean motion.
2. The size of the large eddies is comparable with the dimensions of the neighbouring objects or the dimensions of the flow passage.
3. The size of the smallest eddies can be of the order of 5 mm to 10 mm.

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

55. Ans: (b)

Sol: Correlation studies reveal that the turbulent motion is composed of eddies which are convected by the mean motion. The eddies vary widely in their size. The size of the large eddies is comparable with the dimensions of the neighbouring objects or the dimensions of the flow passage. The size of the smallest eddies can be of the order of 1 mm or less. However, the smallest eddies are much larger than the molecular mean free paths and the turbulent motion obeys the principles of continuum mechanics.

56. In a fully developed flow through a pipe of 300 mm diameter, the shear stress at the wall is 50 Pa. The Darcy's friction factor is 0.05. What is the rate of flow in case of water flowing through the pipe?
(a) 2.8 m^3/s (b) 1.8 m^3/s
(c) 1.5 m^3/s (d) 0.8 m^3/s

56. Ans: (*)

Sol: $$\frac{\tau_o}{\frac{1}{2}\rho V^2} = \frac{f}{4}$$

$$\Rightarrow \frac{8\tau_o}{\rho V^2} = f$$

$$V = \sqrt{\frac{8\tau_o}{\rho f}} = \sqrt{\frac{8 \times 50}{1000 \times 0.05}} = \sqrt{8}\ m/s$$

$$Q = A\,V$$

$$= \frac{\pi d^2}{4} V = \frac{\pi \times 0.3^2 \times \sqrt{8}}{4}$$

$$Q = 0.2\ m^3/s$$

57. Consider the following statements regarding friction factor :
1. In turbulent flow, friction factor depends on both the Reynolds number and the roughness of the pipe surface.
2. Moody's diagram can be used for predicting the values of friction factor.
3. Roughness in commercial pipes is due to the protrusions at the surface which are random both in size and spacing.

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

57. Ans: (d)

Sol:
- In turbulent flow, the friction factor depends on Reynolds number and relative roughness (ε/D)
- Moody's diagram is used to determine the friction factor for pipe flow using Reynolds number and relative roughness.
- Commercial pipe roughness is caused by surface protrusions that are irregular/random in size and spacing.

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58. Which one of the following is used to find the increase in entropy between absolute zero and any given state ?
(a) Spectrometric data
(b) Calorimetric data
(c) Isometric data
(d) Polymetric data

58. Ans: (b)

Sol: Heat and temperature are calorimetric data.
By using heat and temperature, entropy change can be decided.

$$dS = \frac{\delta Q}{T}$$

59. Critical value of Reynolds number at which boundary layer changes from laminar to turbulence does not depend on :
(a) Surface roughness
(b) Pressure gradient
(c) Plate curvature
(d) Flow velocity

59. Ans: (d)

Sol: The critical Reynolds number marks the transition of boundary layer flow from laminar to turbulent. It depends on factors like surface roughness, pressure gradient, and plate curvature, which affect flow stability. However, it does not depend on flow velocity, because velocity is already included in the Reynolds number definition. Therefore, changes in velocity do not alter the critical Reynolds number value itself.

60. Which one of the following statements is correct, if the heat is added to a system at a high temperature?
(a) The increase in entropy is greater.
(b) The increase in entropy is small.
(c) There is no change in entropy.
(d) The entropy becomes zero.

60. Ans: (b)

Sol: $dS = \frac{\delta Q}{T}$

If same heat transfer occurs at higher temperature, entropy change is less.

61. Consider the following statements regarding location of cooling tower :
1. The tower site should be such that it allows unrestricted air flow to the tower.
2. Open space, as far as possible, should be allowed between the cooling tower louvers and nearby structures.
3. The tower should be located in such a way that the piping running to and from it is minimum.

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

61. Ans: (d)

Sol: All the 3 statements given are correct.

62. In which one of the following types of systems is the water drawn directly from the upstream side of a river pumped through the condenser and is discharged to the downstream side of the river at temperature 5°C to 10°C in excess of inlet temperature ?
(a) Open or once-through system
(b) Closed system
(c) Mixed system
(d) Air cooling system

62. Ans: (a)

Sol: The condenser which receives the water from river (source) as a coolent and exhausted to the same river is called open (or) once through system.

63. Consider the following statements regarding the applications of solar photovoltaic (PV) systems :
1. Solar PV systems convert solar energy directly into electrical energy.
2. A solar cell is basically an electrical current source, driven by a flux of radiation.
3. The efficiency of solar cells is more than 50%.

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

63. Ans: (a)

Sol: **Solar PV systems:**
1. Solar PV system convert solar energy directly into electrical energy.
2. The efficiency of solar cell is less than 25%.

64. Consider the following statements regarding geothermal energy :
1. As per US Geological Survey, the entire heat content of the Earth's crust up to a depth of 2 km above 20°C is defined as geothermal resource.
2. Geothermal energy is considered an inexhaustible and renewable source.
3. Geothermal energy is available in low-grade thermal energy form on the surface of the Earth.

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

64. Ans: (c)

Sol: **Geothermal Energy:**
1. Geothermal Energy is considered an inexhaustible and renewable source.
2. Geothermal Energy is low grade thermal energy.
3. As per US Geological survey, the entire heat content of the Earth's crust upto a depth of 3 km to 10 km above 20°C is defined as geothermal source.

65. High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for :
(a) Heat swimming pools
(b) Heating water and air for residential and commercial use
(c) Electric power production
(d) Heating and melting of snow on roads

65. Ans: (c)

Sol: High temperature collectors like parabolic through central tower etc concentrate sunlight using mirrors or lenses and are generally used for Electric power production.

66. How much electricity consumption can be cut back with the installation of solar flat-plate collectors in any household instead of power-grid geysers?
(a) 20% (b) 10%
(c) 30% (d) 15%

66. Ans: (a)

Sol: Nearly 20% of electricity consumption can be cut back with the installation of solar flat plate collectors in any household instead of power grid geysers.

67. If the lifetime of the solar power plant and the interest rate is known, then the cost per kWh can be calculated and is known as :
(a) Levelised energy cost
(b) Total energy cost
(c) Life-cycle cost
(d) Operational cost

67. Ans: (a)

Sol: Levelised energy cost (LEC):

$$LEC = \frac{\text{The average total cost to build, operate and decomposition a power plant over its life time}}{\text{Total energy produced}}$$

68. Operational Energy Footprint (OEF) in solar thermal energy is also called :
(a) Life-Cycle Assessment (LCA)
(b) Carbon Clawback Ratio (CCR)
(c) Energy Parasitics Ratio (EPR)
(d) Operational Carbon Footprint (OCF)

68. Ans: (c)

Sol: Operational Energy Foot Print (OEF) in solar thermal energy is also called Energy parasitics Ratio. It is an energy consumed during operation of the system itself (Pumps, tracking motors, control systems etc)

69. Consider the following statements regarding solar trackers:
1. A solar tracker is a generic term used to describe devices that orient various payloads toward the Sun.
2. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices.
3. In flat-panel photovoltaic (PV) applications, trackers are used to maximize the angle of incidence between the incoming light and a photovoltaic panel.

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

69. Ans: (b)

Sol: Three statements are correct but statement 2 is not related to solar tracking system.

70. Consider the following statements regarding photovoltaic cells :
1. Photovoltaic cells are made of at least two layers of semiconductor material.
2. When two modules are wired in parallel, their current remains constant while the voltage varies.

Which of the above statements is/are correct ?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

70. Ans: (a)

Sol: Photovoltaic cell:

The PV cells are made of at least two layers of semiconducting materials.

When two modules are wired in parallel, the voltage remains constant while current increases.

71. The performance of photovoltaic modules and arrays under standard test conditions (STC) are defined by module operating temperature of:
(a) 200°C (b) 225°C
(c) 250°C (d) 275°C

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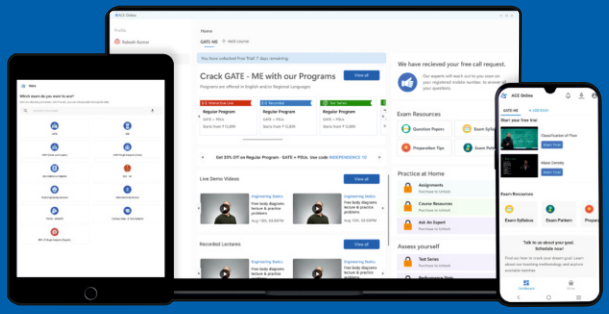

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71. Ans: (*)

Sol: Standard testing conditions of PV cell
→ Solar irradiance (G) = 1000 W/m^2
→ Cell temperature (T_C) = 25°C
→ Air mass ratio = 1.5

72. Consider the following statements regarding the basic features that characterize lift and drag:
1. Drag is in the direction of airflow.
2. Lift is perpendicular to the direction of airflow.
3. Lift devices are generally less efficient than drag devices.

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

72. Ans: (a)

Sol: **Drag force:** The force on an object opposing the motion of the object. In a frame of reference moving with the object, this is the force on the object in the direction of flow.
Lift force: The net aerodynamic force on an object perpendicular to the motion of the object.
Lift devices are more efficient because they generate force mainly from pressure differences with less energy loss, whereas drag devices rely on resistance to flow, causing higher energy losses.

73. Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of carbon monoxide (CO), hydrogen (H_2) and traces of methane (CH_4). This mixture is called :
(a) Producer gas (b) Biogas
(c) Carbonaceous (d) Syngas

73. Ans: (a)

Sol: **Producer gas:**
It is produced by partially combustion of solid carbonaceous fuels like coal, charcoal, biomass with limited supply of air.
CO = 18 - 22% ; N_2 = 45 - 55%
H_2 = 10 - 15% ; CO_2 = 8 - 12%

74. A formula for the speed of a tidal wave in a sea of uniform depth (h_o) is obtained from shallow water theory as:
(a) $\sqrt{gh_o}$ (b) $g\sqrt{h_o}$
(c) $h_o\sqrt{g}$ (d) gh_0

74. Ans: (a)

Sol: The speed of a tidal wave in a sea of uniform depth (h_o) is $\sqrt{gh_o}$.

75. Consider the following statements regarding fuel cells :
1. A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent.
2. Hydrogen is the most common fuel, but hydrocarbons such as natural gas and alcohols like methanol are sometimes used.
3. Electrons are drawn from the cathode to the anode through an external circuit, producing alternating current electricity.

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

75. Ans: (a)

Sol: Statement (3) is not correct, the Electrons are drawn form the anode to the cathode through an external circuit.

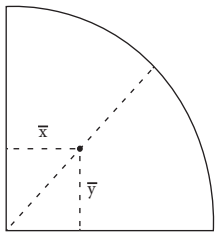
76. What is the centroid on the line of symmetry from the center distance of a quarter circle, if the radius is R ?

(a) $2R/3\pi$ (b) $3R/2\pi$

(c) $3R/4\pi$ (d) $4R/3\pi$

76. Ans: (d)

Sol:



$\bar{x} = \bar{y} = \frac{4r}{3\pi}$

77. If a particle has an initial velocity of $V_0 = 12$ m/s to the right, at $S_0 = 0$, what is the position when t = 10 s, if $a = 2$ m/s^2 to the left?

(a) 20 m (b) 15 m

(c) 25 m (d) 30 m

77. Ans: (a)

Sol: Given: u = 12 m/s (right is positive)

t = 10 sec

a = –2 m/s^2 (left is negative)

$S = ut + \frac{1}{2}at^2$

$S = 12 \times 10 - \frac{1}{2} \times 2 \times 10^2$

$= 120 - 100 = 20$ m

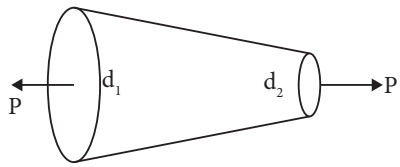
78. What is the extension 'Δ' for a uniformly tapering rod of length 'L' with diameter 'd_1' at one end, to a diameter 'd_2' at the other end when the member is subjected to an axial tensile load 'P' and the modulus of elasticity is E?

(a) $4PL/\pi Ed_1d_2$ (b) $4PE/\pi Ld_1d_2$

(c) $4Pd_1d_2/\pi EL$ (d) $4EL/\pi Pd_1d_2$

78. Ans: (a)

Sol:



Standard formula for deformation,

$\delta\ell = \frac{PL}{\frac{\pi}{4}d_1d_2E}$

$= \frac{4PL}{\pi d_1d_2E}$

79. Consider the following statements regarding thermal stresses:

1. If the temperature change is uniform throughout the body, the thermal strain is also uniform.
2. If thermal deformation is permitted to occur freely, no internal forces will be induced in the body, and there will be no strain and no stress.
3. If the deformation of a body is restricted, either totally or partially, internal forces will develop that oppose the thermal expansion or contraction. The stresses caused by these internal forces are known as thermal stresses.

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

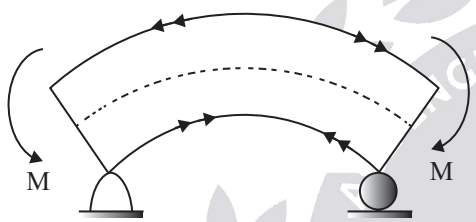
79. Ans: (c)

Sol: Statement '2' is wrong because for free expansion no stress develops but stain = αt develops

80. The bending moment that tends to bend the beam to produce convexity above the centre line is known as :
(a) Sagging bending moment
(b) Hogging bending moment
(c) Twisting bending moment
(d) Pure bending moment

80. Ans: (b)

Sol:

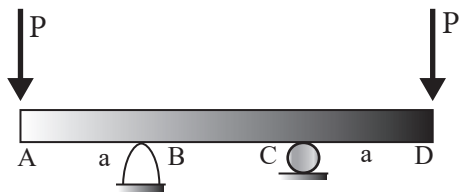


Convexity above centre line is hogging B.M.

81. The type of bending that occurs between the two supports of an overhanging beam with constant bending moment and no shear stress between the supports and carries equal amount of point load at its each end is :
(a) Pure bending
(b) Pure torsion
(c) Twisting moment
(d) Sagging bending moment

81. Ans: (a)

Sol:



Segment BC subjected to pure bending as no shear force exists between B to C.
No shear + Constant BM = Pure bending.

82. A seamless pipe of 80 cm diameter contains a fluid under a pressure of 20 kg/cm^2. If the permissible tensile stress is 1000 kg/cm^2, what is the minimum thickness of the pipe?
(a) 0.8 cm
(b) 0.6 cm
(c) 0.7 cm
(d) 0.5 cm

82. Ans: (a)

Sol: Given: $d = 80$ cm,
$p = 20$ kg/cm^2,
$\sigma_{alw} = 1000$ kg/cm^2,
$t_{min} = ?$

Hoop stress in pipe,

$$\sigma_h = \frac{pd}{2t} \le \sigma_{alw}$$

$$\frac{20 \times 80}{2 \times t} = 1000$$

$$t = \frac{800}{1000} = \frac{8}{10} = 0.8 \text{ cm}$$

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83. Consider the following statements regarding the centre of gravity and centroid :
1. Centroid of an area does not lie on the axis of symmetry if it exits.
2. Centre of gravity of a body is a point through which the resultant gravitational force acts for any orientation of the body.
3. Centroid is a point in a line plane area volume such that the moment of area about any axis through that point is zero.

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

83. Ans: (b)

Sol: Statement 1 is false because centroid always lies on the axis of symmetry.

84. Consider the following statements regarding laws of friction :
1. The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two contacting surfaces.
2. The force of friction is independent of the area of contact between the two surfaces.
3. The force of friction does not depend upon the smoothness/roughness of the surfaces.

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

84. Ans: (a)

Sol: Limiting friction,

$$f = \mu N$$

$$\Rightarrow \frac{f}{N} = \mu = \text{constant}$$

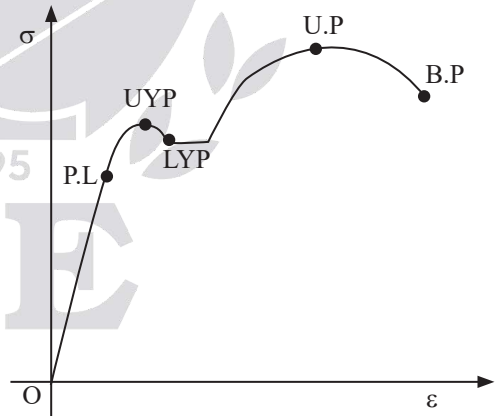
The force of friction is independent of the area of contact and just depends on nature of surface in contact.

85. Consider the following statements regarding simple stresses and strains :
1. Limit of proportionality is the limiting value of the stress up to which stress is proportional to strain.
2. Upper yield point is the stage at which the stress remains same but strain increases for some time.
3. The stress at which the specimen finally fails is called breaking point.

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

85. Ans: (c)

Sol:



Hook's law: Stress is proportional to strain upto proportional limit.

The lower yield point is the stage at which stress remain constant but strain increases for some time.

The stress at which specimen fails is called breaking point.

86. Consider the following statements regarding beams:
1. Propped cantilever is a beam with one end fixed and the other end simply supported.
2. Over-hanging beam is the beam with projections beyond the support.

Which of the above statements is/are correct ?
(a) Both 1 and 2 (b) 1 only
(c) 2 only (d) Neither 1 nor 2

86. Ans: (a)

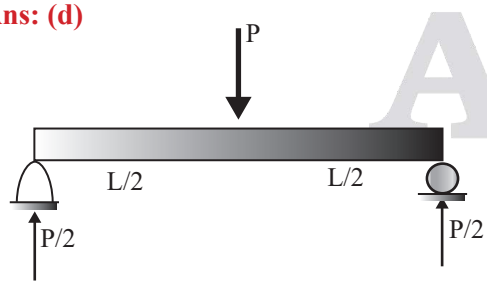
Sol:

- A propped cantilever is a beam fixed at one end and supported (usually simply supported/roller) at the other end.
- An overhanging beam has a portion that extends beyond one or both supports.

87. A circular steel pipe is used as a simply supported beam over an effective span of 2 m. If its maximum moment carrying capacity is 2261 Nm, what is the maximum concentrated load that can be carried by it at mid span ?
(a) 9.86 kN (b) 7.16 kN
(c) 2.84 kN (d) 4.52 kN

87. Ans: (d)

Sol:



$$M_{max} = \frac{P}{2} \times \frac{L}{2} = \frac{PL}{4} = 2261$$

$$= P \times \frac{2}{4} = 2.26 \text{ kN} - \text{m}$$

$$P = 4.52 \text{ kN}$$

88. Which of the following steps is/are utilized in the determination of the three directional indices in crystallographic directions?
1. A vector of convenient length is positioned such that it passes through the origin of the coordinate system. Any vector is translated throughout the crystal lattice without alteration, if parallelism is maintained.
2. The length of the vector projection on each of the three axes is determined; these are measured in terms of the unit cell dimensions a, b, and c.

Select the correct answer using the code given below:
(a) 1 only
(b) 2 only
(c) Neither 1 nor 2
(d) Both 1 and 2

88. Ans: (d)

Sol: A crystallographic direction is defined as a line between two points, or a vector.
The following steps are utilized in the determination of the three directional indices:
1. A vector of convenient length is positioned such that it passes through the origin of the coordinate system. Any vector may be translated throughout the crystal lattice without alteration, if parallelism is maintained.
2. The length of the vector projection on each of the three axes is determined; these are measured in terms the unit cell dimensions a, b and c.
3. These three numbers are multiplied or divided by a common factor to reduce them to the smallest integer values.

4. The three indices not separated by commas are enclosed in square brackets. thus: [u, v, w]. The u, v and w integers correspond to the reduced projections along the x, y and z axes. respectively.

89. In which type of bonding are the stable electron configurations assumed by the sharing of electrons between adjacent atoms?
(a) Metallic bonding
(b) Covalent bonding
(c) Chemical bonding
(d) Ionic bonding

89. Ans: (b)

Sol: A covalent bond is a chemical bond formed by sharing of valence electrons between atoms.

90. The ratio of volume of atoms in a unit cell to the total unit cell volume is called :
(a) Atomic packing factor
(b) Isotopic packing factor
(c) Interatomic packing factor
(d) Ionic packing factor

90. Ans: (a)

Sol: Atomic packing factor

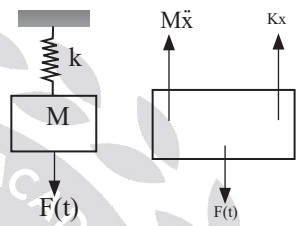
$$= \frac{\text{Total volume of atoms in a unit cell}}{\text{Volume of unit cell}}$$

91. Consider the following statements regarding forces acting on the mass attached to a helical spring, suspended from a fixed support with no damping subjected to an oscillating force :
1. The mass experiences impressed oscillating force.
2. The mass experiences inertia force.
3. The mass experiences restoring force.

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

91. Ans: (d)

Sol:



$F_I + F_R = F(t)$

$M\ddot{x} + kx = F(t)$

All the forces will be acting.

92. A refrigerator unit of mass 35 kg is to be supported on three springs, each having the same spring stiffness. The natural circular frequency of vibration is 15.15 rad/s. The stiffness of each spring is:
(a) 1.2 N/mm (b) 1.9 N/mm
(c) 2.1 N/mm (d) 2.7 N/mm

92. Ans: (d)

Sol: Given:

Mass, m = 35 kg

Spring stiffness, $k_e = 3$ K

Natural frequency, $\omega_n = 15.15$ rad/sec

$$\omega_n = \sqrt{\frac{k_e}{m}}$$

$$(15.15)^2 = \frac{3K}{35}$$

$\Rightarrow K = 2677.7$ N/m = 2.7 N/mm

93. Consider the following statements regarding whirling of a shaft :
1. The bending of the shaft depends upon the eccentricity of the centre of mass of the rotor, as also upon the speed at which the shaft rotates.
2. Whirling speed is the speed at which the shaft does not vibrate at all.
3. When rotor is mounted on a shaft, its centre of mass does not usually coincide with centre line of the shaft.

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

93. Ans: (b)

Sol: $y = \frac{e\,r^2}{1 - r^2}$

y is dependent on e (eccentricity) and $r = \frac{\omega}{\omega_n}$.

Whirling speed is the speed at which the shaft vibrates violently.

94. Consider the following statements regarding gear terminology :
1. Rack is a part of gear wheel of infinite diameter.
2. Module is the ratio of the number of teeth to pitch diameter in mm.
3. The point of contact of two pitch circles is known as pitch 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

94. Ans: (b)

Sol: Statement 1 and 3 are correct.

Module is ratio of pitch diameter to number of teeth.

95. Consider the following statements regarding interference in involute gears :
1. Mating of two non-conjugate teeth is known as interference.
2. If any of the two surfaces is not an involute, the two surfaces would not touch each other tangentially and the transmission of power would not be proper.
3. The common normal is also a common tangent to the two base circles and does not pass through the pitch 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

95. Ans: (a)

Sol: Statement 1 and 2 are correct.

The common normal is also a common tangent to the two base circles and pass through the pitch point.

96. Consider the following statements regarding terminology of worm gears :
1. In single helix, the axial pitch is equal to lead.
2. Lead angle is an angle at which the teeth are inclined to the normal to the axis of rotation.
3. In case of worms, the lead angle is very small and the helix angle approaches to zero.

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

96. Ans: (a)

Sol: Statement 1 and 2 are correct.

Lead angle + Helix angle = 90°

Lead angle can be very small and helix angle can approach to 90° only.

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97. What happens to the motion of the piston in a slider-crank mechanism when the length of the connecting rod is large?
(a) The piston's motion becomes more irregular.
(b) The piston executes a simple harmonic motion.
(c) The piston's motion becomes curvilinear motion.
(d) The piston's motion becomes circular.

97. Ans: (b)

Sol: $x = (l + r) - (l\cos\beta + r\cos\theta)$

$$x = r\left(\left(1+\frac{\ell}{r}\right)-\left(\frac{\ell}{r}\frac{\sqrt{n^2-\sin^2\theta}}{n}+\cos\theta\right)\right)$$

$$\sin\beta = \frac{\sin\theta}{n} \Rightarrow \cos\beta = \sqrt{\frac{n^2-\sin^2\theta}{n}}$$

$$x = r\left((1+n)-\left(n\frac{\sqrt{n^2-\sin^2\theta}}{n}+\cos\theta\right)\right)$$

$\sqrt{n^2-\sin^2\theta} \cong n$

So, $x = r(1 + n - n - \cos\theta)$

$= r(1 - \cos\theta)$

98. Match the following lists for the relation between endurance limit (σ_e) and ultimate tensile strength (σ_u):

List - I (Material)	List-II (Relation)
P. Steel	1. $\sigma_e = 0.5\,\sigma_u$
Q. Cast steel	2. $\sigma_e = 0.4\,\sigma_u$
R. Cast iron	3. $\sigma_e = 0.35\,\sigma_u$

Select the correct answer using the code given below:

	P	Q	R		P	Q	R
(a)	2	1	3	(b)	1	2	3
(c)	2	3	1	(d)	3	1	2

98. Ans: (b)

Sol: Relationship between Endurance strength (Se) and Tensile ultimate strength (S_{ut}) for:

Mild steel: $Se = 0.5\,S_{ut}$

Cast steel: $Se \approx (0.4 \text{ to } 0.5) \times S_{ut}$

It behaves similarly to wrought steel but often has lower fatigue performance due to surface irregularities and internal casting micro-defects.

Cast Iron: $Se \approx (0.35 \text{ to } 0.45) \times S_{ut}$

It generally has lower fatigue strength than steel and often lacks a sharply defined endurance limit compared to mild steel.

Grey cast Iron: $Se \approx (0.25 \text{ to } 0.4) \times S_{ut}$

99. When designing machine parts, it is desirable to keep the stress lower than the maximum stress at which failure of the material takes place. This stress is known as :
(a) Ultimate stress (b) Working stress
(c) Yield stress (d) Shear stress

99. Ans: (b)

Sol: Working stress (or) allowable stress during design is the maximum possible stress that a material is safely permitted to withstand while in service.

100. The maximum principal or normal stress (σ_{tl}) in a bi-axial stress system for ductile materials is (where σ_{yt} = yield point stress in tension, σ_u = ultimate stress, F.S = factor of safety):
(a) σ_{yt} /F.S (b) σ_u /F.S
(c) F.S /σ_{yt} (d) F.S /σ_u

100. Ans: (a)

Sol: For ductile materials, yield point is considered as the point of failure according to design.

$\therefore \sigma_{tl}$ = maximum principle stress

$\therefore$ According to design,

$$\sigma_{tl} = \frac{Syt}{F.S}$$

F.S = factor of safety.

101. What is the type of the theory in which, the failure or yielding occurs at a point in a member when the strain energy per unit volume in a bi-axial stress system reaches the limiting strain energy (i.e. strain energy at the yield point) per unit volume as determined from simple tension test ?
(a) Haigh's Theory
(b) Hencky and Von-Mises Theory
(c) Saint Venant's Theory
(d) Tresca Theory

101. Ans: (a)

Sol: According to Haighs theory, the failure or yielding occurs at a point in a member when the strain energy per unit volume in a bi-axial stress system reaches the limiting strain energy per unit volume as determined from simple tension test.

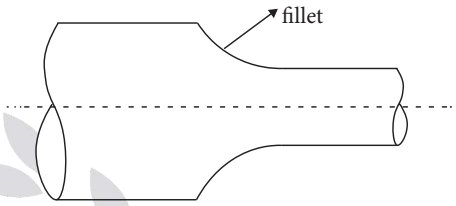
102. Consider the following statements regarding stress concentration :
1. The maximum stress occurs at some point on the fillet and is directed parallel to the boundary at that point.
2. Stress concentration occurs for all kinds of stresses in the presence of fillets, notches, holes, keyways, splines, surface roughness or scratches, etc.
3. In a member with different cross-section under a tensile load, the material near the edges is stressed considerably higher than the average value.

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

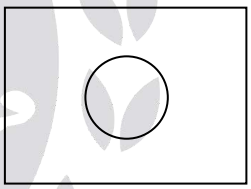
102. Ans: (d)

Sol:

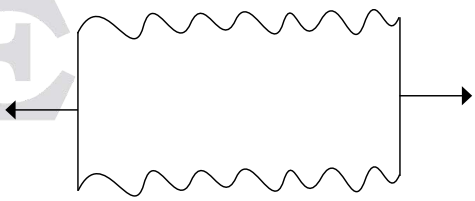
(i) Max stress is possible at the minimum cross-section of fillet and acts parallel or tangential to its boundary.



(ii) Stress concentration occurs when there is changes in cross-section due to the presence of fillets, notches, holes, keyways, splines. surface roughness (or) scratches.



(iii) When the bar is subjected to concentrated load. The stress at the minimum cross-section over the edges carry more stress if the cross-section is varying.



103. Consider the following statements regarding factors to be considered while designing machine parts to avoid fatigue failure:
1. The variation in the size of the component should be as gradual as possible.
2. The holes, notches and other stress raisers should be avoided.
3. The residual tensile stresses over the part's surface increases its fatigue strength.

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

103. Ans: (a)

Sol: To prevent easy Fatigue failure:
(i) The variation in cross-section should be gradual
(ii) The component should be free from defects like pin holes, blow holes, scratches, notches etc.
(iii) The component should be subjected to residual compression to close the existing cracks.

104. A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are $\sigma_t = 120$ MPa. What is the tearing resistance of the plate?
(a) 180 kN (b) 175 kN
(c) 185 kN (d) 170 kN

104. Ans: (a)

Sol: Double riveted $\rightarrow$ n = 2
"n" represents no. of rivets/pitch
Double cover $\rightarrow$ k = 2
"k" represents no. of planes of shear/rivet

Tearing strength

$(F_t) = S_{yt} \times (p - d_n) \times t$

where, d_n = diameter of hole
p = pitch between rivets
t = thickness of plate

$F_t = 120 \times (100 - 25) \times 20$
$= 120 \times \frac{3}{4} \times 100 \times 20$
$= 180 \times 10^3$ N
$= 180$ kN

105. Consider the following statements regarding design of a nut :
1. When a bolt and a nut is made of mild steel, then the effective height of the nut is made equal to the nominal diameter of the bolt.
2. If the nut is made of weaker material than the bolt, then the height of the nut should be smaller.
3. In case a cast iron or aluminium nut is used, then V-threads are permissible only for permanent fastenings, because threads in these materials are damaged due to repeated screwing and unscrewing.

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

105. Ans: (b)

Sol: In the design of nut,
(i) effective height of nut = nominal diameter of bolt (when both bolt and nut are made of same material)
(ii) when bolt and nut are made of different material, If nut is weaker, then effective height of nut > nominal diameter of bolt.

(iii) When aluminum and cast iron are used in V-thread bolts and nuts, they can be easily damaged or stripped with frequent assembly and disassembly. Therefore, their rule is generally restricted to permanent fastings.

106. The atomic packing factor for a face-centered cubic crystal structure is :
(a) 0.62 (b) 0.75
(c) 0.67 (d) 0.74

106. Ans: (d)

Sol:

Crystal Structure	Atomic Packing Factor
Simple Cubic (SC)	0.52
Body-Centered Cubic (BCC)	0.68
Face-Centered Cubic (FCC)	0.74
Hexagonal Close-Packed (HCP)	0.74
Diamond Cubic (DC)	0.34

107. Consider the following statements regarding atomic crystal structures for metals :
1. Zinc has a face-centered cubic crystal structure.
2. Lead has a face-centered cubic crystal structure.
3. Cobalt has a hexagonal close-packed crystal structure.
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

107. Ans: (c)

Sol: Zinc (Zn) has an HCP structure, so statement 1 is not correct.
HCP structure: Eg: Zn, Co, Cd, Be
FCC structure: Eg: Cu, Ag, Pb, Au, Sn

108. Consider the following statements regarding atomic radii for metals :
1. The atomic radii of Tungsten is 0.1371 nm.
2. The atomic radii of Cadmium is 0.1490 nm.
3. The atomic radii of Nickel is 0.1246 nm.
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

108. Ans: (d)

Sol: Standard metallic (atomic) radii values:
Tungsten (W): ≈ 0.137 nm
Cadmium (Cd): ≈ 0.149 nm
Nickel (Ni): ≈ 0.125 nm

109. Consider the following statements regarding pearlite :
1. Pearlite is a microstructural mixture of cementite and ferrite.
2. Fine pearlite is harder and stronger than coarse pearlite.
3. Coarse pearlite is more ductile than fine pearlite.
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

109. Ans: (d)

Sol: **Pearlite:** Pearlite is an eutectoid mixture of ferrite and cementite.
→ Fine pearlite is harder and stronger than coarse pearlite. Strength and hardness increase by reducing grain size.
→ Ductility and toughness increase by increasing grain size. Coarse pearlite is more ductile than fine pearlite.

110. Consider the following statements regarding anelasticity:
1. For metals the anelastic component is normally small.
2. In anelasticity, deformation will continue after the stress application, and upon load release, some finite time is required for complete recovery.
3. Time-independent elastic behaviour is known as anelasticity.

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

110. Ans: (b)

Sol: Time dependent elastic behaviour is known as anelasticity. For metals, this component is small.

111. A piece of copper, originally 305 mm long is pulled in tension with a stress of 276 MPa. If the deformation is entirely elastic, what is the resultant elongation?
(Take Young's modulus for copper as 110 GPa)
(a) 0.91 mm (b) 0.77 mm
(c) 0.43 mm (d) 0.24 mm

111. Ans: (b)

Sol: Hooks Law,

$$\sigma = E\,\varepsilon$$

$$\sigma = E\frac{\delta\ell}{\ell}$$

$$\delta\ell = \frac{\sigma\ell}{E} = \frac{276 \times 305}{110 \times 10^3} = 0.77 \text{ mm}$$

112. Consider the following statements regarding ductility and brittleness:
1. Ductility is a measure of the degree of plastic deformation that has been sustained at fracture.
2. A material that experiences very little or no plastic deformation upon fracture is termed brittle.
3. Brittleness is expressed quantitatively as either percent elongation or percent reduction in area.

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

112. Ans: (b)

Sol: **Ductility:** It is the ability of material that can generate plastic deformation upto fracture.
Ductility of metal is measured by

$$\%\text{increase in length} = \frac{\delta\ell}{\ell_i} \times 100$$

$$\%\text{reduction in c/s area} = \frac{\delta A}{A_i} \times 100$$

Brittleness: The material generate very little or no plastic deformation upon fracture.

113. Consider the following statements regarding corrosion :
1. Corrosion is defined as the destructive and unintentional attack of a metal.
2. For metallic materials, the corrosion process is normally electrochemical.
3. Metal atoms characteristically give up electrons in deoxidation reaction.

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

113. Ans: (b)

Sol: **Corrosion:** It is an electro-chemical process of unintentional attack of a metal.

Oxidation: $Fe \rightarrow Fe^{2+} + 2e^-$

Reduction: $2H^+ + 2e^- \rightarrow H_2$

A metal atom give up electrons in oxidation, not in reduction.

114. Consider the following statements regarding corrosion environments:
1. Seawater is generally less corrosive than freshwater.
2. Nickel-chromium-molybdenum alloys are highly corrosion resistant in seawater.
3. Moisture containing dissolved oxygen is the primary corrosive agent.

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

114. Ans: (c)

Sol: Corrosion environments
1. Seawater is generally more corrosive than freshwater.
2. Nickel-chromium-molybdenum alloys are highly corrosion resistant in seawater.
3. Moisture containing dissolved oxygen is the primary corrosive agent.

115. Consider the following statements regarding corrosion prevention:
1. One of the most effective means of corrosion prevention is cathodic protection.
2. Inhibitors are normally used in closed systems such as automobile radiators.
3. Physical barriers to corrosion are applied on surfaces in the form of films and coatings.

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

115. Ans: (d)

Sol: Corrosion prevention method:
- Cathodic protection is a widely used and effective corrosion prevention method.
- Corrosion inhibitors are commonly used in closed systems like automobile radiators.
- Physical barriers such as films and coatings protect metal surfaces from corrosion.

116. Consider the following statements regarding kinematic pairs according to nature of contact:
1. Shaft rotating in a bearing is an example of lower pair.
2. Universal joint is an example of higher pair.
3. Wheel rolling on surface is an example of higher pair.

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

116. Ans: (b)

Sol: A universal joint (Hooke's joint) is made of revolute (turning) pairs, where the elements have surface contact. Hence, it is a lower pair, not a higher pair.

117. The degree of freedom of a linkage having 11 links and 4 loops is:

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

117. Ans: (b)

Sol: Given: $N = 11, L = 4$

$DOF = N - (2L + 1)$

$= 11 - (2 \times 4 + 1)$

$= 11 - 9 = 2$

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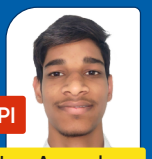

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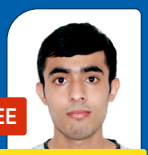

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Total 41 Ranks in Top-10

(ME: 10 | EC: 04 | EE: 05 | CE: 04 | CS: 02 | IN: 05 | DA: 01 | PI: 07 | XE: 02 | ES: 01)

118. When one of the turning pairs of a four-bar chain is replaced by a sliding pair, then it is known as :
(a) Rotary engine
(b) Slider-crank chain
(c) Oscillating cylinder engine
(d) Quick-return mechanism

118. Ans: (b)

Sol: A four-bar chain normally has 4 turning pairs (revolute joints).
If one revolute (turning) pair is replaced by a sliding (prismatic) pair, the new mechanism becomes a single slider-crank mechanism.

119. Consider the following statements regarding coriolis acceleration component :
1. The coriolis acceleration component is positive, if the link rotates clockwise and the slider moves radially outwards.
2. It is positive, if both angular velocity and linear velocity are either positive or negative.
3. The coriolis acceleration component is not dependent on the angular velocity.

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

119. Ans: (a)

Sol: Coriolis acceleration depends on angular velocity of the rotating link and linear velocity of the slider.

120. The gun is designed such that on firing, the barrel recoils against the spring. A dashpot, at the end of recoil, allows the barrel to come back to its initial position within the minimum time without any oscillation. The gun barrel has mass of 500 kg and a recoil spring of 300 N/mm. The barrel recoils 1 m on firing. What is the initial recoil velocity of the gun barrel?
(a) 29.4 m/s (b) 24.5 m/s
(c) 26.8 m/s (d) 28.1 m/s

120. Ans: (b)

Sol: Initial K.E = Spring P.E

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

$$v = \sqrt{\frac{k}{m}} \times x$$

$$= \sqrt{\frac{300 \times 10^3}{500}} \times 1$$

$$= \sqrt{\frac{3000}{5}}$$

$$= \sqrt{600} = 24.5 \text{ m/s}$$

121. Consider the following statements regarding types of cutting fluids :
1. Emulsion is a mixture of oil, water and additives.
2. Emulsions are used for low-speed operations where temperature rise is not significant.
3. Synthetics are chemicals with additives, diluted in water and containing no oil.

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

121. Ans: (c)

Sol: Emulsions are generally used for high-speed operations because water provides good cooling. They are not specifically meant for low-speed operations.
Emulsion (soluble oil) is a mixture of oil, water, and additives such as emulsifiers and corrosion inhibitors.
Synthetic cutting fluids are chemical solutions diluted in water and contain no mineral oil.

122. Consider the following statements regarding machine cell design :
1. Single machine cell consists of one machine, supporting fixtures and tooling.
2. Group machine cell with manual handling includes more than one machine to process one or more part families.
3. Flexible manufacturing system combines automated processing stations with a fully integrated handling system.

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

122. Ans: (d)

Sol: A Flexible Manufacturing System (FMS) with a fully integrated handling system is a high-level, computer-controlled manufacturing setup that automates not just the production process (machining), but also the movement, storage, and loading/unloading of parts.

123. How many BCD numbers can be accommodated in an 8-bit register in the 8085 microprocessor?
(a) One (b) Two
(c) Three (d) Four

123. Ans: (b)

Sol: An 8-bit register can hold 8 binary bits.
In BCD (Binary Coded Decimal):
Each decimal digit (0–9) needs 4 bits.
So in 8 bits:

$$8 \div 4 = 2$$

8 ÷ 4 = 2 BCD digits

That means an 8-bit register in the 8085 microprocessor can accommodate two BCD numbers.

124. In which of the following robots, it is possible to position the wrist through two rotations and one linear actuation?
(a) Articulated Geometry Robot
(b) Cartesian Coordinate Robot
(c) Cylindrical Coordinate Robot
(d) Polar Coordinate Robot

124. Ans: (d)

Sol: Articulated Geometry Robot → 3 rotational motions
Cartesian Coordinate Robot → 3 linear motions
Cylindrical Coordinate Robot → 1 rotation + 2 linear motions
Polar Coordinate Robot → 2 rotations + 1 linear motion

125. In systems, peripheral I/O becomes essential if the memory requirement is :
(a) 64 K (b) 92 K
(c) 16 K (d) 8 K

125. Ans: (a)

Sol: This is about 8085 microprocessor addressing.
- The 8085 has a 16-bit address bus, so it can address a maximum of 64K (2^{16}) memory locations
- If the entire 64K address space is used for memory, there are no address locations left for memory-mapped I/O.
- In that case, peripheral (isolated) I/O becomes essential, because it uses a separate I/O address space.

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126. A dial gauge is used to measure the pressure in a vessel. The readings are 7.0 kN/m^2 for a dial reading of zero and 31.0 kN/m^2 for a reading of 120. If the variation is linear, what is the value of pressure for a dial reading of 90?
(a) 12.5 kN/m^2 (b) 15 kN/m^2
(c) 25 kN/m^2 (d) 7.5 kN/m^2

126. Ans: (c)

Sol: Given: By using linear interpolation
Dial reading 0 → pressure = 7.0 kN/m^2
Dial reading 120 → pressure = 31.0 kN/m^2
Change in pressure = 31 – 7 = 24 kN/m^2
Change in diameter reading = 120
Pressure per unit dial = $\frac{24}{120}$ = 0.2 kN/m^2
For a dial reading of 90°.
Increase in pressure = 90 × 0.2 = 18.0 kN/m^2
Pressure at 90° = 7 + 18 = 25 kN/m^2

127. Consider the following statements regarding the LVDT accelerometer:
1. It has lower natural frequency.
2. No error occurs due to moving contacts.
3. It is used in low-frequency measurements.
Which of the above statements is/are correct?
(a) 2 only (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

127. Ans: (c)

Sol: Accelerometers must have a natural frequency much higher than the frequency of acceleration being measured. Since LVDT accelerometers have lower natural frequency, they are not suitable for high-frequency measurements
LVDT is a contactless transducer, so there's no wear or contact-related error.
LVDT accelerometers are mainly used for low-frequency acceleration measurements.

128. Which one of the following is an analog input device?
(a) Potentiometer
(b) Pressure switch
(c) Temperature switch
(d) Encoder

128. Ans: (a)

Sol: A potentiometer is an analog input device because it gives a continuous output, while the others give only digital signals.

129. Which one of the following devices is used for switching AC voltages and acts as a two-way SCR with one gate connected at the output unit?
(a) Relay output circuit
(b) Transistor output unit
(c) Triac output unit
(d) DAC interface

129. Ans: (c)

Sol: The device described is:
- Used for switching AC voltages
- Acts like two SCRs connected in opposite directions
- Has a single gate.

130. What is the force needed to apply to a piston of 2 cm radius in order to result a force of 8000 N at the working piston of radius 8 cm ?
(a) 1000 N (b) 250 N
(c) 2000 N (d) 500 N

130. Ans: (d)

Sol: **Pascal law:**

Pressure intensity is same for static fluid,

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_1}{\pi \times 0.02^2} = \frac{8000}{\pi \times 0.08^2}$$

$$F_1 = 500 \text{ N}$$

131. The filter at the pump outlet which can remove the contaminants passing through or generated by the pump in order to protect the valves, is known as :
(a) Inlet line filter
(b) Pressure line filter
(c) Return line filter
(d) Mechanical filter

131. Ans: (b)

Sol: The filter that protects the valves from contaminants generated by the pump or passing through it is placed after the pump on the pressure side.

- Inlet line filter → before the pump, protects the pump itself
- Pressure line filter → after the pump, protects valves and system
- Return line filter → on the return line to tank
- Mechanical filter → generic term

132. Consider the following statements regarding colour detection :
1. Colour is the brain's physiological and psychological interpretation of light.
2. A colour is the measurement of a light's chrominance and luminance.
3. The chrominance characterizes the property of energy, while the luminance characterizes the property of pure colour.

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

132. Ans: (a)

Sol: Colour is how our brain interprets light → Correct
Colour can be described by luminance (brightness) and chrominance (color itself)
Statement 3 is incorrect because luminance shows brightness (energy) and chrominance shows the actual color, not the other way around.

133. A current flowing in a conductor, such as a beam, is deflected by a magnetic field. This effect is called:
(a) Hall effect
(b) Bernoulli effect
(c) Push effect
(d) Beam effect

133. Ans: (a)

Sol: The phenomenon where a current-carrying conductor is deflected by a magnetic field is called the Hall effect.

134. DCV as a processing element can generate or cancel or redirect signals depending on the desired control conditions and a processing element is normally known as :
(a) Flow control valve
(b) Non-return valve
(c) Logic valve
(d) Pressure control valve

134. Ans: (c)

Sol: A valve that controls the flow of signals based on logic, which in hydraulic or pneumatic systems is called a logic valve.

- Flow control valve → controls the rate of flow, not logic
- Non-return valve → allows flow only in one direction
- Logic valve → processes signals, generates/ cancels/redirects them
- Pressure control valve → maintains or limits pressure

135. Which one of the following is an application of the continuous path robot ?
(a) Pick and place
(b) Tracing of contours
(c) Interact with the environment
(d) Make decisions

135. Ans: (b)

Sol: A continuous path robot can follow a smooth, precise path, controlling the motion of its end effector at every point along the path.
Pick and place → only moves between points → point-to-point robot.
Tracing of contours → moves along a continuous path.
Interact with the environment / Make decisions → more related to intelligent robots.

136. A line shaft rotating at 200 r.p.m. is to transmit 20 kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 42 MPa. What is the torque transmitted by the shaft?
(a) $(\pi/4)$ kN-m (b) $(4/\pi)$ kN-m
(c) $(\pi/3)$ kN-m (d) $(3/\pi)$ kN-m

136. Ans: (d)

Sol: N = speed of shaft = 120 rpm
P = power transmitted = 20 kW
S_{ys} = Allowable shear stress
For safety
Torque transmitted ≤ twisting strength of shaft

$$\text{Torque transmitted, } T = \frac{60P}{2\pi N}$$

$$T = \frac{60 \times 20 \times 10^3}{2 \times \pi \times 200}$$

$$= \frac{3}{\pi} \times 10^3 \text{ N} - \text{m}$$

$$= \frac{3}{\pi} \text{ kN} - \text{m}$$

137. Consider the following statements regarding gear teeth :
1. The beam strength of gear teeth is determined from a Lewis equation.
2. The load carrying ability of the toothed gears as determined by Lewis equation gives satisfactory results.
3. Lewis assumed that as the load is being transmitted from one gear to another, it is all given and taken by several teeth.

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

137. Ans: (a)

Sol:

- Lewis actually made a simplifying assumption that the entire load is transmitted by a single pair of teeth at any given time, specifically when the contact is at the tip of the tooth, which is the position of maximum bending moment. This is a conservative assumption used in the derivation of the equation. In reality, load sharing occurs

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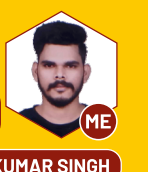
AIR 10 —  ME — AMIT KUMAR SINGH

Total 36 Ranks in Top-10 (E&T:10 | EE: 09 | CE:07 | ME: 10)

among several teeth, but the Lewis equation simplifies this for calculation purposes. However, statement 3 is incorrect.

- The beam strength of gear teeth is determined from a Lewis equation.
- The load carrying ability of the toothed gears as determined by Lewis equation gives satisfactory results.

138. Consider the following statements regarding heat generated in a journal bearing:
1. For a well-designed bearing, the temperature of the oil film should be more than 100°C, otherwise the viscosity of the oil decreases rapidly and the operation of the bearing is found to suffer.
2. The temperature of the oil film is often called the operating temperature of the bearing.
3. In case the temperature of the oil film is higher, then the bearing is cooled by circulating water through coils built in the bearing.

Which of the above statements are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

138. Ans: (c)

Sol:

- The temperature of the oil film in a well-designed bearing should typically be below 1000C (or often a maximum of around 600C to 800C in practice) to maintain adequate viscosity and prevent rapid degradation of the lubricant. Statement 1 is incorrect.
- The temperature of the oil film is often called the operating temperature of the bearing.
- In case the temperature of the oil film is higher, then the bearing is cooled by circulating water through coils built in the bearing.

139. For a single row deep groove ball bearing with a radial load of 4000 N and an axial load of 5000 N, operating at a speed of 1600 r.p.m. for an average life of 5 years at 10 hours per day, and assuming uniform and steady load and 300 working days per year, what is the life of the bearing in hours?
(a) 10000 hours (b) 25000 hours
(c) 15000 hours (d) 20000 hours

139. Ans: (c)

Sol: k = 3 (Ball bearing)

$$L_{rating} = \frac{L_{avg}}{5}$$

$$= 10 \text{ hrs/day} \times 300 \frac{\text{days}}{\text{year}} \times 5 \text{ years}$$

$$= 15000 \text{ hrs}$$

140. Which type of clutches are frequently applied to sprocket wheels, gears and pulleys?
(a) Jaw clutches
(b) Cone clutches
(c) Plate clutches
(d) Centrifugal clutches

140. Ans: (a)

Sol: Jaw clutches are a type of positive clutch that transmit power by the interlocking of jaws. They are commonly used with sprocket wheels, gears and pulleys because they provide a secure, non-slip connection once engaged. Unlike friction clutches, they do not rely on friction to transmit torque and are suitable for applications where engagement is made at lower speeds or when stopped.

141. Consider the following statements regarding metal-casting, processes and equipment :
1. Expendable moulds typically are made of sand, plaster, ceramic, and similar materials and are generally mixed with various binders.
2. Permanent moulds are made of metals that maintain their strength at high temperatures.
3. A typical sand mould consists of 50% sand, 30% clay, and 20% water.

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

141. Ans: (a)

Sol: Around 70 to 85 % of molding sand is filled by using silica sand. Clay is present around 10 to 20%. Water or Sodium Silicate is generally around 3 to 6%.

142. Consider the following statements regarding sand casting :
1. Typical applications of sand casting include large turbine impellers and propellers.
2. Most sand casting operations use silica sand as the mould material.
3. Sand having fine, round grains can be packed closely and, thus, forms a smooth mould surface.

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

142. Ans: (d)

Sol: Sand-casting process used for manufacturing of impellers, diffusers, rotors, mixers and other components for the energy industry, such as blades for Kaplan or Francis turbines.

143. Consider the following statements regarding techniques for strengthening and annealing glass :
1. In thermal tempering process, the surfaces of the hot glass are cooled rapidly by a blast of air.
2. The higher the coefficient of thermal expansion of the glass and the higher its thermal conductivity, the lower will be the level of residual stresses developed, and hence, the weaker the glass becomes.
3. Because of the high amount of energy stored in residual stresses, tempered glass shatters into a large number of pieces when broken.

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

143. Ans: (c)

Sol: In the thermal tempering process, the surfaces of the hot glass are rapidly cooled by a blast of air or a liquid bath, which induces compressive stresses on the surface and tensile stresses in the core, strengthening the glass. Statement 1 is CORRECT.
The higher the coefficient of thermal expansion and thermal conductivity, the higher the level of residual stresses developed during rapid cooling, thus making the glass stronger, not weaker. Statement 2 is INCORRECT.
Tempered glass is designed to shatter into a large number of small, relatively harmless pieces when broken, due to the high amount of stored residual stress energy released upon failure. Statement 3 is CORRECT.

144. Consider the following statements regarding moulds in sand casting :
1. Two-piece moulds consist of a drag on top and a cope at the bottom.
2. Through the sprue, molten metal flows downward.
3. Risers supply additional molten metal to the casting as it shrinks during solidification.

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

144. Ans: (b)

Sol: Riser acts as a reservoir for supplying molten metal to the casting cavity for compensating liquid shrinkage taking place during solidification.

145. Consider the following statements regarding measurement standards :
1. Resolution is the smallest difference in dimensions that the measuring instrument can detect or distinguish.
2. Precision is the degree to which the instrument gives repeated measurements of the same standard.

Which of the above statements is/are correct ?
(a) 1 only (b) 2 only
(c) Neither 1 nor 2 (d) Both 1 and 2

145. Ans: (d)

Sol: **Resolution:** This term refers to the smallest change in the physical quantity being measured that an instrument can reliably detect and indicate. For example, if a digital scale shows weights in increments of 0.01g, its resolution is 0.01g.

Precision: This is a measure of the consistency and repeatability of a measurement system. If you measure the same standard multiple times and the results are very close to each other, the instrument is considered to have high precision. It does not necessarily mean the measurement is "correct" (which would be accuracy), but rather that the results are reproducible.

146. Consider the following basic elements of a flexible manufacturing system:
1. Workstations and cells
2. Automated handling and transport of materials and parts
3. Control system

Which of the above elements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

146. Ans: (d)

Sol: A Flexible Manufacturing System (FMS) typically has three basic elements:
Workstations and cells – where parts are processed
Automated material handling and transport – moves parts between stations
Control system – coordinates the whole system

147. Consider the following statements regarding cutting processes:
1. In turning process, the workpiece is rotated and a cutting tool removes a layer of material.
2. In slab milling process, a rotating cutting tool removes a layer of material from the surface of the workpiece.
3. In end milling process, the cutting tool moves radially inward and separates the right piece from the bulk of the blank.

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

147. Ans: (a)

Sol: In turning, the workpiece rotates and a stationary cutting tool removes material.

In slab milling (plain milling), a rotating cutter removes material from the surface of the workpiece

End milling uses a rotating cutter with cutting edges at the end and periphery to machine slots, pockets, etc. The description given ("tool moves radially inward and separates the part from the blank") corresponds to operations like parting-off, not end milling.

148. Which one of the following processes is used to reduce vibration and chatter in machining operations?

(a) Machining process (b) Damping process

(c) Turning process (d) Knurling process

148. Ans: (b)

Sol: Vibration and chatter in machining are minimized by introducing energy dissipation in the system, which is achieved through damping.

Machining process — general term, not specific to vibration reduction

Damping process — absorbs vibration energy and reduces chatter

Turning process — a machining operation, does not inherently reduce vibration

Knurling process — surface finishing operation

149. Consider the following statements regarding sawing:

1. Vertical band saws are used for straight as well as contour cutting of flat sheets and other parts, supported on a horizontal table.
2. Friction sawing is a process in which a mild-steel blade rubs against the workpiece at speeds of up to 7,600 m/min.
3. Friction sawing process is suitable for non-ferrous metals.

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

149. Ans: (a)

Sol: Vertical band saws are used for straight and contour cutting; the workpiece is supported on a horizontal table and moved manually.

In friction sawing, a mild-steel blade runs at very high speeds (up to about 7,600 m/min), generating heat by rubbing and softening the material for cutting.

Friction sawing is mainly suitable for ferrous materials (e.g., steels). It is not generally preferred for non-ferrous metals.

150. Consider the following statements regarding forced vibration :

1. Forced vibration is generally caused by some periodic applied force present in the machine tool, such as that from gear drives.
2. The amplitude of vibration can be increased by increasing the stiffness or by damping the system.
3. The basic solution to forced vibration is to isolate or remove the forcing element.

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

150. Ans: (c)

Sol: Amplitude of forced vibration is inversely proportional to stiffness and damping.

Statement 1 and 3 are correct.

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