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PRE GATE - 2018
Questions with Detailed Solutions

MECHANICAL ENGINEERING

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PRE GATE - 2018

Mechanical Engineering (MC)

The GA section consists of 10 questions. Questions 1 to 5 are of 1 mark each, and Questions 6 to 10 are of 2 marks each.

01. ***Choose the most appropriate word from the options given below to complete the following sentence:***

If I had known that you were coming, I ______________ you at the airport.

(A) would have met (B) shall have met (C) would meet (D) would have meeting

Ans: (A)

Exp: Conditional tense type three should be if clause (had+v3) and the main clause (would+have+v3)

02. ***In the following sentence certain parts are underlined and marked P, Q and R. One of the parts may contain error or may not be acceptable in standard written communication.***

Select the part containing an error. Choose D as your answer if there is no error.

They found (P) that five prisoners escaped (Q) the previous night. (R) No error (D)

(A) P (B) Q

(C) R (D) No error

Ans: (B)

Exp: In part 'Q' it should be 'prisoners had escaped' because the earlier action of the past should be in past perfect tense (had + v3).

03. ***The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair.***

LAVA : VOLCANO ::

(A) ice : glass

(B) cascade : precipice

(C) steam : geyser

(D) avalanche : ice

Ans: (C)

Exp: (DEFINING CHARACTERISTIC) A volcano gives out lava (meaning molten rock); a geyser (meaning a natural hot spring) gives out steam.

04. If "JUICE" is coded as "19-41-17-5-9", then "TOY" will be coded as

(A) 39-29-49 (B) 41-31-51

(C) 13-23-3 (D) 15-25-5

Ans: (A)

Sol:

AS,

10	21	9	3	5
J	U	I	C	E
↓	↓	↓	↓	↓
10×2	21×2	9×2	3×2	5×2
↓–1	↓–1	↓–1	↓–1	↓–1
19	41	17	5	9

Same as,

20	15	25
T	O	Y
↓	↓	↓
20×2	15×2	25×2
↓–1	↓–1	↓–1
39	29	49

But in option (B)

20	15	25
T	O	Y
↓	↓	↓
20×2	15×2	25×2
↓+1	↓+1	↓–1
41	31	51

It is not in that code

Option (C) and (D) are not correct

05. ***Fill in the blanks with an appropriate idiom***

Let us have your terms ____________

(A) through thick and thin

(B) in black and white

(C) ins and outs

(D) at cross-purposes

Ans: (B)

DLOA: through thick and thin means under all conditions

DLOB: correct answer - in black and white means in writing

DLOC: ins and outs means full details

DLOD: at cross-purposes means misunderstand each other

So the right option is 'B'

06. **Statement:** These apples are too expensive to be bad.

Which of the following can be logically inferred from the above statement?

I. The higher the selling price, the superior is the quality of the commodity.

II. when apples are in short supply, the prices go up.

(A) only I (B) only II

(C) I & II (D) None of the above

Ans: (A)

Exp: The second conclusion is irrelevant. The first is the meaning of the given statement. 'Too expensive to be bad' means that it can't be bad because it is expensive.

07. A postman walked 7 km north from the post office to reach Mr. Singh's house. He then took a left turn and walked 4 km to reach Mr. Kumar's house. He then took a right turn and walked 3 km to reach Mr. Sharma's house. The distance between Mr. Sharma's and Mr. Singh's house is ______

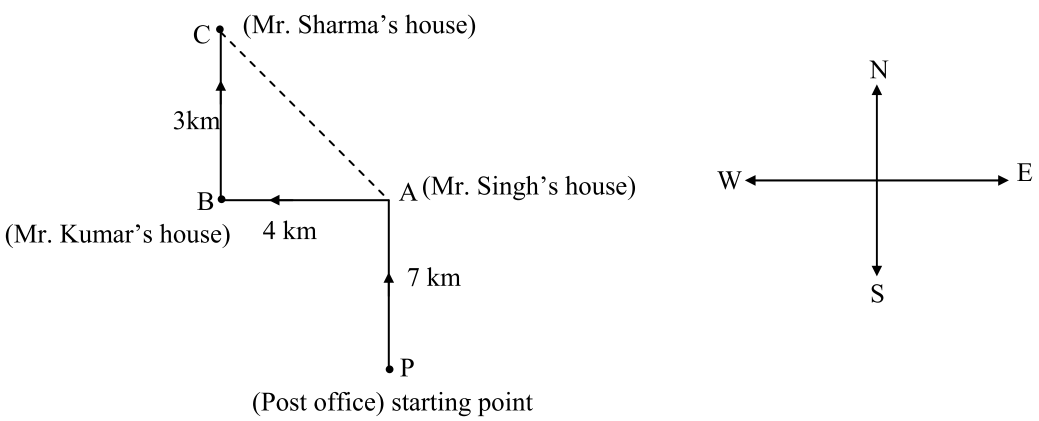
(A) 5 km (B) 6 km

(C) 4 km (D) 7 km

Ans: (A)

Sol:

Let the postman started from the point P which denote post office.



We have to find the distance between A and C so, applying Pythagoras theorem,

$AC^2 = AB^2 + BC^2 = 16 + 9$

$AC^2 = 25$

$AC = \sqrt{25} = 5$ cm

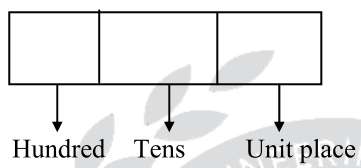
So, distance between Mr. Sharma's and Mr. Singh's house is 5 km.

08. How many 3-digit even number can be formed from the digits 1, 2, 3, 4, 5, 6, if the digits can be repeated?

(A) 216 (B) 108 (C) 96 (D) 54

Ans: (B)

Sol:



We know that, a number is called even, if its unit's place is occupied by an even digit (i.e) 2,4,6

So, for unit place, we have 3 options

For tens place, there are 6 options

For hundred place, there are 6 options

[repetition allowed]

∴ Total number of ways in which 3 digit even numbers can be formed = $3 \times 6 \times 6 = 108$

09. Examine the information given below

All the leaders are believable

Some believable persons are intelligent

Which of the following is a valid conclusion regarding the above arguments?

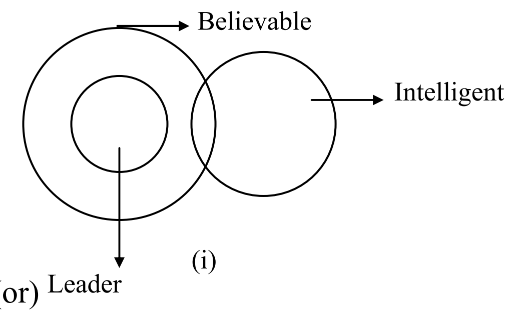
(A) All the leaders are intelligent (B) some leaders are believable

(C) All the intelligent persons are leaders (D) some believable persons are leaders

Ans: (D)

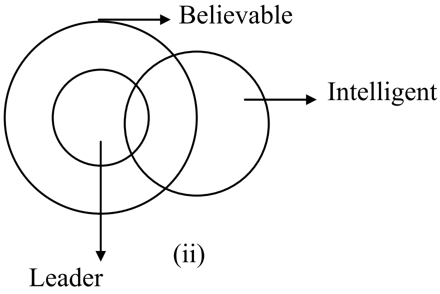
Sol: The given statements can be represented as

Case – I



(or)

Case – II



From above two diagrams

Hence, option (D) is correct

10. A shopkeeper sells note books at the rate of ₹457 each and earns a commission of 4%. He also sells pencil boxes at the rate of ₹80 each and earns a commission of 20%. How much amount of commission will he earn in two weeks, if he sells 10 note books and 6 pencil boxes a day?

(A) ₹1956 (B) ₹1586

(C) ₹1496 (D) None of these

Ans: (D)

Sol: S.P of the note book = ₹457

$\therefore$ Commission on one note book = ₹ $\frac{4\times 457}{100}$

and commission on 10 note books = $\frac{10\times 4\times 457}{100}$ = ₹ 182.80

and S.P of the pencil box = ₹80

$\therefore$ Commission on one pencil box = ₹ $\frac{80\times 20}{100}$

Commission on 6 pencil boxes = $\frac{80\times 20\times 6}{100}$ = ₹96

Hence, total commission of one day = (182.80+96) = ₹ 278.80

Thus, total commission of two weeks = 278.80× 14 = ₹3903.20

Option (A) is not correct

Option (B) is not correct

Option (C) is not correct

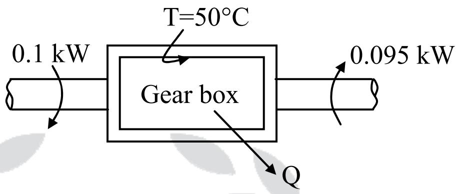
$\therefore$ None of these is the answer

The subject specific section of ME consists of 55 questions, out of which question numbers 1 to 25 are of 1 mark each, while question numbers 26 to 55 are of 2 marks each

01. A gear box operating at steady state receives 0.1 kW along input shaft and delivers 0.095 kW along output shaft. The outer surface of the gear box is at 50°C. The rate at which entropy is produced for gear box is __________ W/K.

01. Ans: 0.0155 [Range: 0.014 to 0.016]

Sol: At steady state,



Heat transfer from gear box is

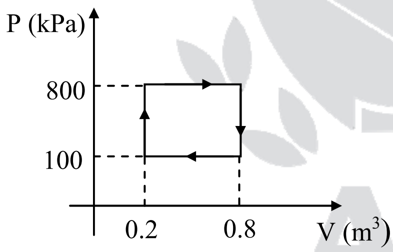
$Q = W_1 - W_2 = 0.1 - 0.095$

$= 0.005 \text{ kW} = 5 \text{ W}$

Entropy produced is

$$\therefore \quad \Delta s = \frac{5}{(273+50)} = 0.0155 \text{ W/K}$$

02. For the hypothetical air standard cycle shown in the diagram below, the mean effective pressure (in kPa) is ________.



02. Ans: 700 [Range: 700 to 700]

Sol: Given data, $P_1 = 100$ kPa, $P_2 = 800$ kPa,

$V_1 = 0.2 \text{ m}^3$, $V_2 = 0.8 \text{ m}^3$

Mean effective Pressure,

$$MEP = \frac{\text{Work done per cycle}}{\text{stroke volume}}$$

$$= \frac{(P_2 - P_1)(V_2 - V_1)}{(V_2 - V_1)} = P_2 - P_1$$

$= 800 - 100 = 700$ kPa

03. Principal stresses at a point in three dimensional loading are σ_1 = 80 MPa, σ_2 = 40 MPa and σ_3 = –40 MPa. The normal stress (in MPa) on maximum shear stress plane is _______

03. Ans: 20 [Range: 20 to 20]

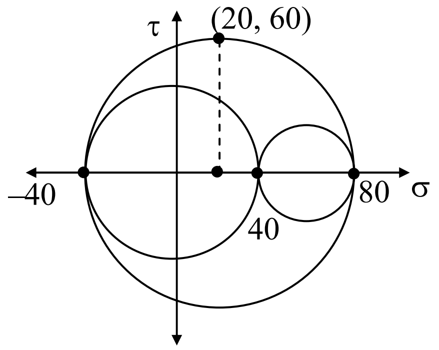
Sol:

Given data:

σ_1 = 80 MPa,

σ_2 = 40 MPa,

σ_3 = –40 MPa

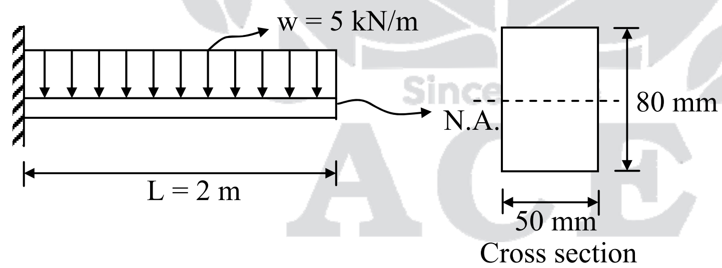


Largest Mohr's circle is considered to calculate maximum shear stress.

The normal stress on maximum shear stress plane is centre of the largest Mohr's circle.

i.e., $\frac{80+(-40)}{2}$ = 20 MPa

04. A cantilever beam of length 2 m and rectangular cross section 50 mm × 80 mm, carries uniformly distributed load of intensity 5 kN/m as shown in the diagram below. The maximum shear stress (in MPa) at neutral axis is_______.



04. Ans: 3.75 [Range: 3.74 to 3.76]

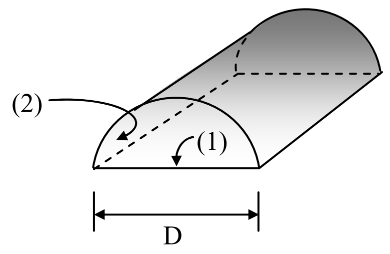
Sol: The transverse shear stress is present at neutral axis, its value is maximum at support where shear force is maximum

$$(\tau_{max})_{N.A} = \frac{3}{2}(\tau_{avg})$$

$$= \frac{3}{2} \times \frac{wL}{A}$$

$$= \frac{3}{2} \times \left[\frac{5\times10^3\times2}{0.05\times0.08}\right] = 3.75 \text{ MPa}$$

05. The view factor from curved surface to itself, for a very long duct of semi circular cross-section with its diameter 'D' as shown in figure, is ________ (neglect end effects and round the answer to two decimal places).



05. Ans: 0.36 [Range: 0.34 to 0.38]

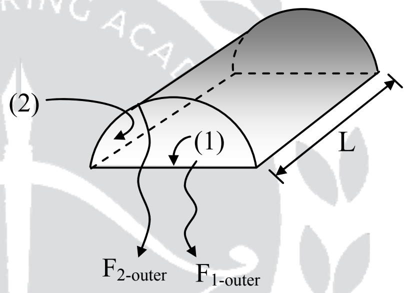
Sol: $F_{1-2} = 1$ (from the geometry and neglecting end effects)

$F_{1\text{-outer}} = 0$ and $F_{2\text{-outer}} = 0$ (neglecting end effects)

Using reciprocity theorem:

$A_1 F_{1-2} = A_2 F_{2-1}$

$$D \times L \times 1 = \left(\frac{\pi \times D \times L}{2}\right) \times F_{2-1}$$



(Assuming, length of the duct = L)

$$F_{2-1} = \frac{2}{\pi}$$

Using Summation rule:

$F_{2-1} + F_{2-2} = 1$

$F_{2-2} = 1 - F_{2-1} = 1 - \dfrac{2}{\pi}$

$F_{2-2} = 0.36$

06. The actual sales of a product for six consecutive months were given as 90, 130, 120, 125, 130, 145. The forecast for 7th month using five month moving average method is ________

06. Ans: 130 [Range: 130 to 130]

Sol: $$F_7 = \frac{D_6 + D_5 + D_4 + D_3 + D_2}{5}$$

$$= \frac{145 + 130 + 125 + 120 + 130}{5} = 130$$

07. In a single server queuing model, the mean arrival rate is 6/hour and arrival follows Poisson distribution. The mean service time is 5 minutes and it follows exponential distribution. The mean waiting time (in minutes) in the queue will be _________ .

07. Ans: 5 [Range: 5 to 5]

Sol: $\lambda = 6$ /hr ,

$$\mu = \frac{1}{5} \times 60 = 12/\text{hr}$$,

Traffic intensity, $\rho = \frac{\lambda}{\mu} = \frac{6}{12} = 0.5$

Average number of customer in the system, $L_s = \frac{\rho}{1-\rho} = \frac{0.5}{1-0.5} = 1$

Expected waiting time in the system, $W_s = \frac{L_s}{\lambda} = \frac{1}{6}$

Mean waiting time in the queue , $W_q = \rho . W_s$

$$= 0.5 \times \frac{1}{6} = \frac{1}{12}\text{hr} = 5 \text{ min}$$

08. A particle travels in a circle of radius 20 cm at a speed that uniformly increases. If the speed changes from 5 m/s to 6 m/s in 2 sec, the angular acceleration (in rad/sec^2) is ______.

08. Ans: 2.5 [Range: 2.4 to 2.6]

Sol: The tangential acceleration is given by

$$a_t = \frac{dv}{dt} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{6-5}{2} = 0.5 \text{m/s}^2$$

Thus, angular acceleration,

$$\alpha = \frac{a_t}{r} = \frac{0.5}{0.2} = 2.5 \text{rad/sec}^2$$

09. A Pitot-static probe is placed in an air stream with velocity 10 m/s and density 1.2 kg/m^3. The U tube manometer attached with the probe has water as manometric fluid. Assuming probe factor to be '1', the reading indicated by the manometer (in mm, rounded upto 2 decimal places) is_________. (Assume g = 10 m/s^2)

09. Ans: 6 [Range: 5.9 to 6.1]

Sol: For static Pitot tube with manometer

$$V = C\sqrt{2g\left(\frac{\rho_m}{\rho} - 1\right).x}$$

$$10 = 1\sqrt{2\times 10\left(\frac{1000}{1.2} - 1\right)x}$$

$\Rightarrow$ $x = 6.01 \times 10^{-3}$ m

$\Rightarrow$ x = 6 mm

10. The mean value of Rolle's theorem for the function $f(x) = \frac{\sin x}{e^x}$ in [0, π] is _______radian.

10. Ans: 0.785 [Range: 0.78 to 0.79]

Sol: By Rolle's theorem,

$$f'(c) = 0$$

$$e^{-c}(\cos c - \sin c) = 0$$

$$\Rightarrow \cos c - \sin c = 0$$

$$\Rightarrow \frac{\sin c}{\cos c} = 1$$

$$\Rightarrow \tan c = 1$$

$$\Rightarrow c = \frac{\pi}{4} \in (0, \pi)$$

$$\Rightarrow c = 0.785 \text{ radian}$$

11. Which of the following is correct dimension of term $\rho C_p \nabla^2 T$ in MLTθ system. (Where ρ = density, C_p = specific heat capacity, T = temperature)

(A) $M^1L^{-3}T^{-2}\theta^1$

(B) $ML^{-2}T^{-2}\theta^1$

(C) $ML^{-3}T^{-2}\theta^0$

(D) None of the above

11. Ans: (C)

Sol: $\nabla^2 T = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}$

The dimension of each term for example can be calculated as

$$\frac{\partial^2 T}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial T}{\partial x}\right)$$

$$= \frac{1}{L} \times \frac{\theta}{L} = L^{-2}\theta$$

$$\therefore \rho C_p \nabla^2 T = \left(\frac{kg}{m^3}\right) \times \left(\frac{J}{kg.K}\right) \times \left(\frac{K}{m^2}\right)$$

$$= \left(\frac{kg}{m^3}\right) \times \frac{\left(\frac{kg.m}{s^2}.m\right)}{kg.K} \times \frac{K}{m^2}$$

$$= \frac{kg}{m^3 s^2}$$

$$= M^1 L^{-3} T^{-2} \theta^0$$

DISTRACTOR LOGIC:

DLOA : If unit of $\frac{\partial^2 T}{\partial x^2}$ is taken as $\frac{K^2}{m^2}$, then option A is obtained

DLOB : If unit of $\frac{\partial^2 T}{\partial x^2}$ is taken as $\frac{K^2}{m}$, then option B is obtained

DLOC : Correct option

DLOD : If any other mistake is done then option D can be considered

12. For a laminar flow of a given liquid through circular pipe of a given length, if the discharge is increased to four times and the diameter is increased to twice then the head loss in the pipe becomes ‘x’ times of the original head loss. What is the value of ‘x’?

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$ (C) 1 (D) 8

12. Ans: (A)

Sol: For laminar flow through circular pipe,

$$h_f = \frac{\Delta P}{\rho g} = \frac{\left(\frac{32\mu V L}{D^2}\right)}{\rho g} = \frac{32\mu\left(\frac{Q}{\frac{\pi}{4}D^2}\right).L}{\rho g D^2} = \frac{128\mu Q L}{\rho g \pi D^4}$$

$$\therefore \frac{h_{f2}}{h_{f1}} = \left(\frac{Q_2}{Q_1}\right) \times \left(\frac{D_1}{D_2}\right)^4 = \left(\frac{4}{1}\right)\left(\frac{1}{2}\right)^4 = \frac{1}{4}$$

DISTRACTOR LOGIC :

DLOA : Correct answer

DLOB : If $h_f = \dfrac{fLQ^2}{12.1\times D^5}$ is used instead of $h_f = \dfrac{128\mu QL}{\rho g \pi D^4}$ then option 'B' is obtained

DLOC : If velocity is not substituted in terms of discharge and $h_f = \dfrac{32\mu VL}{\rho g D^2}$ is used then option 'C' is obtained

DLOD : If velocity is not substituted in terms of discharge and $h_f = \dfrac{fLV^2}{2gD}$ is used then option 'D' is obtained

Note: For laminar flow, if $h_f = \dfrac{fLQ^2}{12.1D^5}$ is used then $f = \dfrac{64}{Re}$ must be used. In this case again correct answer is obtained.

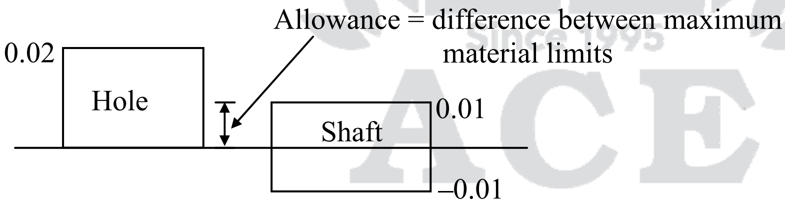
13. Consider a hole – shaft interchangeable assembly as $40\ H^{+0.02}_{0.000}\ j^{+0.01}_{-0.01}$.

The allowance (in microns) in the assembly is

(A) 0.01 (B) 90 (C) 18 (D) 10

13. Ans: (D)

Sol: As clearly seen in the figure,



Allowance = difference between MML of hole and shaft

$= (\text{upper limit})_{shaft} - (\text{lower limit})_{hole}$

$= 0.01 - 0.00 = 0.01\text{mm} = 10\ \mu\text{m}$

DISTRACTOR LOGIC :

DLOA : Incorrect, (mistakes in unit)

DLOB : Incorrect $(\text{Upper limit})_{shaft} - (\text{Lower limit})_{shaft}$

DLOC : Incorrect: $(\text{Upper limit})_{hole} - (\text{Upper limit})_{shaft}$

DLOD : Correct (Explained above)

14. Being the other parameters same, in which one of the following gating systems the metal enters into the cavity with the least velocity?

(A) 1: 2:1 (B) 1:2:3 (C) 1:2:2 (D) 1:4:2

14. Ans: (B)

Sol: Maximum velocity occurs in the gating system where the ratio of cross sectional areas of ingate to sprue is maximum. i.e. area and velocity are inversely proportional.

DISTRACTOR LOGIC :

DLOA : If the ratio is (1/1), Incorrect option

DLOB : Correct (Explained above)

DLOC : If the ratio is (2/1), Incorrect option

DLOD : If the ratio is (2/1), Incorrect option

15. In an undamped vibrating system, the logarithmic decrement is

(A) 0 (B) 1 (C) 2π (D) $\propto$

15. Ans: (A)

Sol: Logarithmic decrement, $\delta = \ell n\left(\frac{x_1}{x_2}\right) = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$

If C = 0 ,

$$\xi = \frac{C}{2\sqrt{km}} = 0$$

$$\delta = \frac{2\pi \times 0}{\sqrt{1-0^2}} = 0$$

DISTRACTOR LOGIC :

DLOA : Correct Option

DLOB : If C = 0 and $\delta = \frac{1}{\sqrt{1-\xi^2}} = 1$

DLOC : If C = 0 and $\delta = 2\pi\sqrt{1-\xi^2} \Rightarrow \delta = 2\pi$

DLOD : If $C = 2\sqrt{km}$, $\xi = 1$, $\delta = \frac{2\pi \times \sqrt{km}}{\sqrt{1-\xi}} = \propto$

16. 0.2 kg of air at 300°C is heated reversibly at constant pressure to 1793°C. The unavailable energy of the heat added is (The ambient temperature is 30°C and c_P = 1.005 kJ/kg.K and c_v = 0.718 kJ/kg.K).

(A) 55.8 kJ (B) 78.1 kJ (C) 22.3 kJ (D) 116.9 kJ

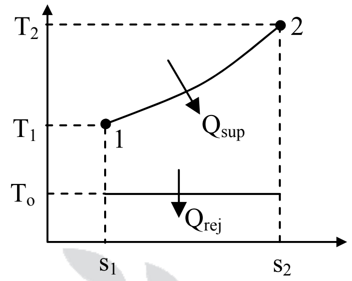
16. Ans: (B)

Sol: Given:

m = 0.2 kg ,

T_1 = 573 K, T_2 = 2066 K, T_o = 303 K

c_p = 1.005 kJ/kg.K



$$s_2 - s_1 = c_p \ell n\left(\frac{T_2}{T_1}\right)$$

$$= 1.005\,\ell n\left(\frac{2066}{573}\right) = 1.289 \text{ kJ/kg.K} \quad (\because P_2 = P_1)$$

Unavailable energy, $Q_{rej} = m\,T_0\,(s_2 - s_1) = 0.2 \times 303 \times 1.289 = 78.1$ kJ

<u>DISTRACTOR LOGIC :</u>

DLOA : Option A is wrong.

$$s_2 - s_1 = C_V\,\ell n\left(\frac{T_2}{T_1}\right)$$

$$Q_{rej} = mT_o(s_2 - s_1) = 0.2\times303\times0.718\times\ell n\frac{2066}{573} = 55.8 \text{ kJ}$$

DLOB : Option B is correct. Explained in the above solution.

DLOC : Option C is wrong: $s_2 - s_1 = R\,\ell n\frac{T_2}{T_1}$

$$Q_{rej} = mT_o(s_2 - s_1) = 0.2\times303\times0.287\,\ell n\left(\frac{2066}{573}\right) = 22.3$$

DLOD : Option D is wrong.

$$s_2 - s_1 = c_V\,\ell n\frac{T_2}{T_1}$$

$$Q_{rej} = mT_o(s_2 - s_1)$$

$$= 0.2\times303\times1.005\,\ell n\left(\frac{2066}{303}\right) \quad (\text{here } T_1 = 303 \text{ K})$$

$$= 116.91 \text{ kJ}$$

17. Choose the CORRECT statement :

(A) Characteristic dimension for a duct in forced convection is $\frac{4A}{P}$ where as, it is $\frac{A}{P}$ for horizontal rectangular plate in free convection.

(B) Characteristic dimension for a duct in forced convection is $\frac{A}{P}$ where as, it is $\frac{4A}{P}$ for horizontal rectangular plate in free convection.

(C) Characteristic dimension, for a duct in forced convection and for a horizontal rectangular plate in free convection, is $\frac{4A}{P}$.

(D) Characteristic dimension, for a duct in forced convection and for a horizontal rectangular plate in free convection, is $\frac{A}{P}$.

Where, A = Cross-sectional area in forced convection and surface area in free convection, P = Perimeter

17. Ans: (A)

Sol:

- Characteristic dimension for a duct in forced convection = $\frac{4A}{P}$
- Characteristic dimension for a horizontal rectangular plate in free convection = $\frac{A}{P}$

DISTRACTOR LOGIC :

DLOA : Correct option.

DLOB : If the characteristic dimensions are interchanged.

DLOC : If both dimensions are considered as $\frac{4A}{P}$.

DLOD : If both the dimensions are considered as $\frac{A}{P}$.

18. The tangential load acting on a spur gear is 200 N with pressure angle 20°. The normal load acting on it is

(A) 72.8 N (B) 212.8 N (C) 584.8 N (D) 549.5 N

18. Ans: (B)

Sol: Normal load (F_n) = $\frac{F_T}{\cos\phi} = \frac{200}{\cos 20^\circ}$

$F_n = 212.8$ N

DISTRACTOR LOGIC :

DLOA : Radial load (F_r) = $F_t \tan\phi$

$F_r = 200 \times \tan 20^\circ = 72.8$ N

DLOB : Correct Answer.

DLOC : $F_n = \frac{F_t}{\sin\phi} = \frac{200}{\sin 20^\circ} = 584.8\text{N}$

DLOD : $F_n = \frac{F_t}{\tan\phi} = \frac{F_t}{\tan 20^\circ} = 549.5\text{N}$

19. In a single cylinder 4 stroke engine, effects of secondary unbalanced forces is minimized by

(A) Partial balancing

(B) Use of large connecting rod to crank length ratio

(C) Use of small connecting rod to crank length ratio

(D) Dynamic splitting of connecting rod mass at its two ends

19. Ans: (B)

Sol: Secondary force = $\frac{mr\omega^2}{n}\cos 2\theta$

where, $n = l/r$, as n is high, secondary force is minimum.

DISTRACTOR LOGIC :

DLOA : Can be confused with balancing of primary forces.

DLOB : Correct option

DLOC : This option can be obtained if secondary force is considered directly proportional to 'n'

DLOD : Dynamic splitting of mass has no relation with balancing of secondary forces.

20. The depth of cut and cutting speed in an orthogonal cutting operation are 0.6 mm and 6 m/s respectively. If thickness of the chip is 0.90 mm, the chip velocity is

(A) 9 m/s (B) 6 m/s (C) 4 m/s (D) 8 m/s

20. Ans: (C)

Sol: Given: Orthogonal cutting is specified in the problem

Depth of cut (d) = Uncut chip thickness (t_1) = 0.6 mm (d = t_1 in orthogonal cutting)

Cutting velocity, V = 6 m/s

Chip thickness, t_2 = 0.90 mm

Chip velocity, V_c = ?

$\Rightarrow$ Chip thickness ratio, $r = \frac{t_1}{t_2} = \frac{0.60}{0.90} = \frac{2}{3}$

$$V_c = rV = \frac{2}{3} \times 6$$

$$V_c = 4 \text{ m/s}$$

DISTRACTOR LOGIC :

DLOA : If ‘r’ is wrongly taken as, $r = \frac{t_2}{t_1} = 1.5$

Then, V_c = 9 m/s

DLOB : Relationship between chip velocity and cutting velocity is wrongly expressed as $V = rV_c$, then V = 6 m/s

DLOC : Correct option

DLOD : Wrong data interpretation.

21. In the iron-iron carbon diagram, on cooling, a solid transforms into two other solid phases at the same time. The reaction is called

(A) Eutectic reaction (B) Eutectoid reaction

(C) Peritetic reaction (D) Perieutectic reaction

21. Ans: (B)

Sol: Eutectoid reaction :

$$\text{solid}(\gamma) \xrightarrow{-\Delta h} \text{solid}(\alpha) + \text{solid}(Fe_3C)$$

γ = austenite , α = Ferrite , Fe_3C = Cementite , $\alpha + Fe_3C$ = Pearlite

DISTRACTOR LOGIC :

DLOA : Eutectic reaction: $\text{Liquid}(L) \xrightarrow{-\Delta h} \text{solid}(\gamma) + \text{solid}(Fe_3C)$

DLOB : Correct option .

DLOC : Peritetic reaction: $\text{Liquid}(L) + \text{solid}(\delta) \xrightarrow{-\Delta h} \text{solid}(\gamma)$

DLOD : Perieutectic reaction: No such reaction exits in iron-carbon diagram

22. If $A = \begin{bmatrix} -3 & 1 \\ 2 & +3 \end{bmatrix}$ then $A^{100} = ?$

(A) $11^{50}\ I$ (B) $11^{100}\ I$ (C) $11^{50}\ A$ (D) $11^{100}\ A$

22. Ans: (A)

Sol: The characteristic equation is

$$|A - \lambda I| = \lambda^2 - 0.\lambda - 11 = 0$$

$$\Rightarrow \lambda^2 - 11 = 0$$

By Cayley-Hamilton theorem

$$A^2 - (11)I = 0$$

$$A^2 = (11)I$$

$$A^{100} = (A^2)^{50} = (11\ I)^{50} = 11^{50}\ I$$

23. The value of the integral $\int_c \frac{\cos z}{(z-\pi)} dz$ where c is |z–1| = 3 is

(A) –2πi (B) 2πi (C) πi (D) –πi

23. Ans: (A)

Sol: The singular point z = π = 3.14 lies inside the circle C: | z –1| = 3

$$\int_c \frac{\cos z}{(z-\pi)} dz = 2\pi i f(\pi) \quad \text{where } f(z) = \cos z$$

$$= 2\pi i \cos(\pi)$$

$$= -2\pi i$$

24. Suppose 'X' is a Poisson random variable and $E(X^2) = 6$ then $P(X \le 1.2)$ is

(A) $2e^{-2}$ (B) $3e^{-3}$ (C) $3e^{-2}$ (D) $2e^{-3}$

24. Ans: (C)

Sol: $V(X) = E(X^2) - (E(X))^2$

$\Rightarrow \lambda = 6 - \lambda^2$ [where λ is the mean of Poisson distribution]

$\Rightarrow \lambda^2 + \lambda - 6 = 0$

$\Rightarrow \lambda = 2$

Thus $P(X \le 1.2) = P(X = 0) + P(X=1)$

$= e^{-2} + 2e^{-2} = 3e^{-2}$

25. The solution of the differential equation $e^{x-y}\,dx + e^{y-x}\,dy = 0$ is

(A) $e^x + e^{-y} = c$ (B) $e^{2x} + e^{-2y} = c$

(C) $e^{2x} + e^{2y} = c$ (D) $e^{-2x} + e^{-2y} = c$

25. Ans: (C)

Sol: $e^{x-y}dx + e^{y-x}dy = 0$

$$\frac{e^x}{e^y}dx + \frac{e^y}{e^x}dy = 0$$

$$\int e^{2x}\,dx + \int e^{2y}\,dy = k$$

$$\frac{e^{2x}}{2} + \frac{e^{2y}}{2} = k$$

$$e^{2x} + e^{2y} = 2k$$

$$e^{2x} + e^{2y} = c$$

(Here c, k are constants)

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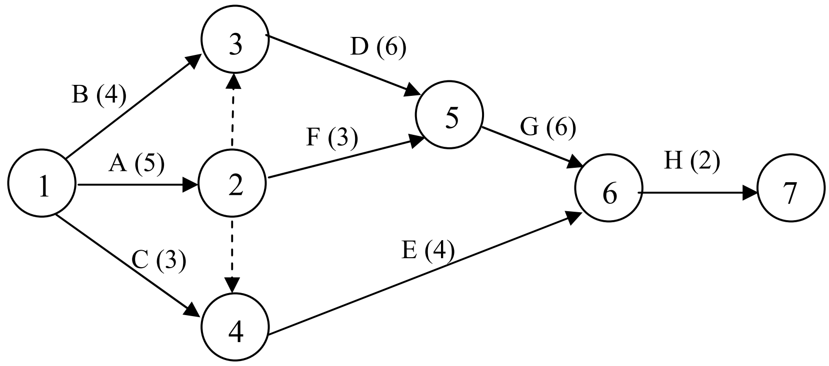
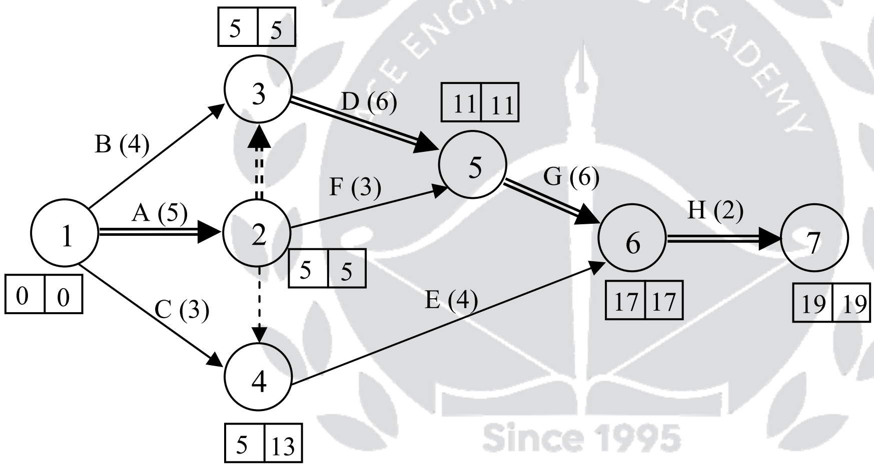
26. Consider the following network as shown in figure below.



The project duration for the network is __________

26. Ans: 19 [Range: 19 to 19]

Sol:



Project duration = 5+ 0 + 6 + 6 + 2 = 19

27. Consider the following Linear Programming (LP) model.

Maximize , $Z = 600 x_1 + 700 x_2$

Subjected to

$6x_1 + 10x_2 \leq 60$

$6x_1 + 8x_2 \leq 48$

$7x_1 + 12x_2 \leq 84$

$x_1 \geq 0 , x_2 \geq 0$

The optimal value of the solution is ______

27. Ans: 4800 [Range: 4799 to 4801]

Sol: Maximize , $Z = 600\,x_1 + 700\,x_2$

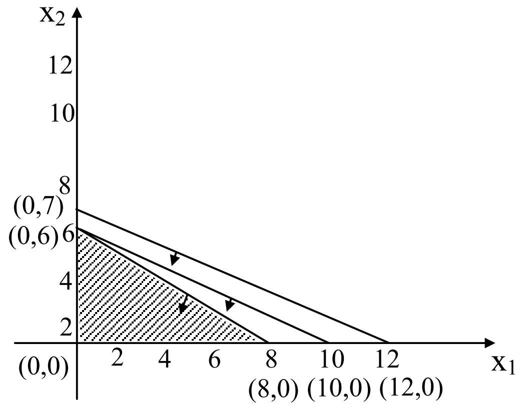
Subject to

$6x_1 + 10x_2 \le 60 \Rightarrow \frac{x_1}{10} + \frac{x_2}{6} \le 1$

$6x_1 + 8x_2 \le 48 \Rightarrow \frac{x_1}{8} + \frac{x_2}{6} \le 1$

$7x_1 + 12x_2 \le 84 \Rightarrow \frac{x_1}{12} + \frac{x_2}{7} \le 1$

$x_1 \ge 0$, $x_2 \ge 0$



$Z(0,0) = 600(0) + 700(0) = 0$

$Z(0,6) = 600(0) + 700(6) = 4200$

$Z(8,0) = 600(8) + 700(0) = 4800$

$\therefore\ Z_{max} = 4800$

28. A gas-turbine power plant operates on a modified Brayton cycle (consisting of high pressure and low pressure turbines) with an overall pressure ratio of 8. Air enters the compressor at 0°C and 100 kPa. The maximum cycle temperature is 1500 K. The compressor and the turbines are isentropic. The high pressure turbine develops just enough power to run the compressor. Assume constant properties for air with c_v = 0.718 kJ/kgK, c_p = 1.005 kJ/kgK, R = 0.287 kJ/kgK, γ = 1.4. The pressure (in kPa) at the exit of the high pressure turbine is__________.

28. Ans: 457 [Range: 454 to 460]

Sol: $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

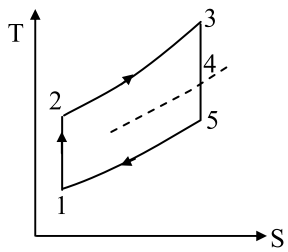
$T_2 = T_1 \times (8)^{\frac{1.4-1}{1.4}} = 494.5\,\text{K}$

Work done by high pressure turbine = Work done on the compressor

$c_p \times (T_3 - T_4) = c_p (T_2 - T_1)$

$1500 - T_4 = 494.5 - 273$

$\Rightarrow\ T_4 = 1278.5$ K



$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}}$

$$\frac{1500}{1278.5} = \left(\frac{P_3}{P_4}\right)^{\frac{1.4-1}{1.4}}$$

$\Rightarrow$ $P_4 = 457$ kPa

29. Air is contained in a cylinder device fitted with a piston-cylinder. The piston initially rests on a set of stops, and a pressure of 300 kPa is required to move the piston. Initially, the air is at 100 kPa and 27°C and occupies a volume of 0.4 m^3. The heat is transferred to the air, which increases its temperature to 1200 K. Assume air has constant specific heats evaluated at 300 K. The magnitude of heat transferred (in kJ) to the air is ___________.

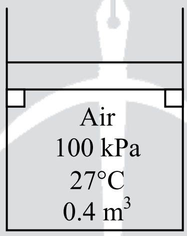
29. Ans: 340 [Range: 339 to 341]

Sol: Intially the pressure of air is 100 kPa. When the heat is supplied to it the pressure goes on increasing, till it reaches 300 kPa. Once piston leaves the stops the pressure become cosntant. Let the temperature at this state be T_2.

$P_1 = 100$ kPa,

$T_1 = 300$ K,

$V_1 = V_2 = 0.4\ m^3$

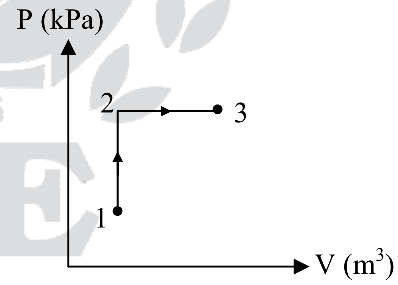


Process 1-2 :

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\Rightarrow T_2 = \frac{P_2}{P_1} \times T_1 = \frac{300}{100} \times 300 = 900\,\text{K}$$

$$\Rightarrow m = \frac{P_1 V_1}{RT_1} = \frac{100 \times 0.4}{0.287 \times 300} = 0.464\,\text{kg}$$



Total heat supplied = $m\, c_v (T_2 - T_1) + m\, c_p (T_3 - T_2)$

$= 0.464 \times 0.717 \times (900 - 300) + 0.464 \times 1.005 \times (1200 - 900)$

$= 340$ kJ

30. Moist air enters the refrigeration coil of a dehumidifier with a flow rate of 2 kg of dry air per second. The air leaves saturated at 15°C. The enthalpies of air entering and leaving the coil are 78 kJ/kgda and 42 kJ/kgda, respectively. The humidity ratio of air entering and leaving the coil are 0.018 and 0.0106 kg vap/kg d.a. The enthalpy of saturated water at 15°C is 62.99 kJ/kg. The refrigeration capacity (in tons) is ____________.

30. Ans: 20.3 [Range: 19 to 21]

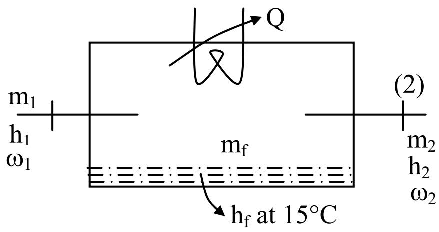
Sol: Given:

Mass of dry air,

$m_a = 0.2$ kg , $h_1 = 72$ kJ/kgda , $h_2 = 42$ kJ/kgda

At 15°C,

$h_f = 62.99$ kgvap/kg d.a, $\omega_1 = 0.018$ kgvap/kg d.a.



From mass balance:

$$(m_{a_1} + m_{\omega_1}) - (m_{a_1} + m_{\omega_2}) = m_f$$

$$m_{\omega_1} - m_{\omega_2} = m_f$$

$$\frac{m_f}{m_a} = \omega_1 - \omega_2 \quad \text{------------(1)}$$

$\omega_2 = 0.0106$ kg vap/kg d.a.

Using energy balance:

$$m_a h_1 = m_a h_2 + m_f h_f + Q \quad \text{----------(2)}$$

$$\therefore m_a h_1 = m_a h_2 + (m_{\omega_1} - m_{\omega_2}) h_f + Q$$

$$Q = m_a[(h_1 - h_2) - (\omega_1 - \omega_2) h_f]$$

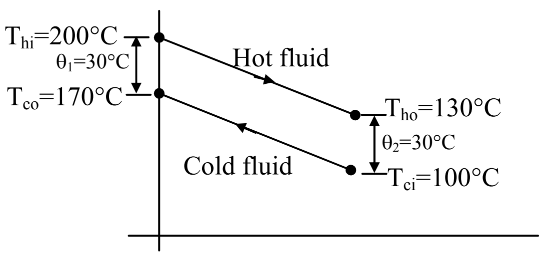
$$Q = 2[(78–42) – (0.018 – 0.0106)\ 62.99] = 71.06 \text{ kW}$$

Refrigeration capacity in tons $= \dfrac{71.06}{3.5} = 20.3$ tons

31. The hot and cold inlet temperatures to a concentric tube heat exchanger are $T_{hi} = 200°C$, $T_{ci} = 100°C$, respectively. The outlet temperatures are $T_{ho} = 130°C$ and $T_{co} = 170°C$. The number of transfer unit (NTU) of the given heat exchanger is ________. (Round to two decimal places)

31. Ans: 2.33 [Range: 2.30 to 2.35]

Sol: The given heat exchanger is counter flow heat exchanger because exit temperature of cold fluid is greater than that of the hot fluid.



$\theta_1 = \theta_2 = \theta_m = 30°C$

LMTD = 30°C

Temperature drop for hot fluid (200 – 130 = 70°C) and temperature raise for cold fluid (170 – 100 = 70°C) is same. Hence, from energy balance, heat capacities are same.

$\therefore$ Heat capacity ratio, $C = \frac{C_{min}}{C_{max}} = \frac{70}{70} = 1$

If C = 1 in counter flow heat exchanger, temperature profile will be linear as show in the figure.

Heat transfer rate = $\dot{m}_h c_{ph} (T_{hi} - T_{ho})$

$UA\theta_m = \dot{m}_h c_{ph} (200 - 130)$

$\frac{UA}{\dot{m}_h c_{ph}} \times 30 = 70$

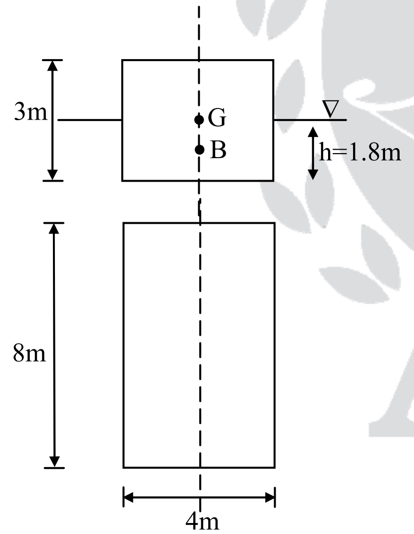
$NTU = \frac{70}{30} = 2.33 \quad \left[\because\ NTU = \frac{UA}{C_{min}}\right]$

NTU = 2.33

32. A wooden block of 3m × 4m × 8m size and 0.6 specific gravity is floating in a fresh water such that its largest face is parallel to the free surface. The metacentric height of the block in meters is_____.

32. Ans: 0.141 [Range: 0.135 to 0.145]

Sol:



Let, h = submerged depth of the block as the block is floating

Weight = buoyancy force

$\Rightarrow \rho_s V_s g = \rho \forall g$

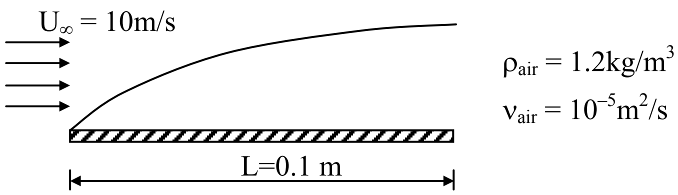
$\Rightarrow 600 \times (3 \times 4 \times 8) = 1000 \times (4 \times 8 \times h)$

$\Rightarrow h = 0.6 \times 3 = 1.8m$

$$GM = \frac{I_{min}}{\forall} - BG = \frac{\left(8 \times \frac{4^3}{12}\right)}{(8 \times 4 \times 1.8)} - \left(\frac{3}{2} - \frac{1.8}{2}\right) = 0.141m$$

33. An air stream with velocity 10m/s and density 1.2kg/m^3 blows over a flat rectangular plate of length 0.1 m as shown in the figure. The correlations for the average drag coefficient (C_D) and the skin friction coefficient (C_f) for laminar and turbulent boundary layer are given below. The shear stress at middle of plate length (in Pa) is______ (Rounded upto two decimal places).

(Assume the kinematic viscosity of air as 10^{-5} m^2/s)



$C_D = \frac{1.328}{\sqrt{Re_L}}$ For Laminar flow , $C_D = \frac{0.074}{(Re_L)^{1/5}}$ For Turbulent flow ,

$C_f = \frac{0.664}{\sqrt{Re_x}}$ For Laminar flow , $C_f = \frac{0.058}{(Re_x)^{1/5}}$ For Turbulent flow.

33. Ans: 0.18 [Range: 0.17 to 0.19]

Sol: $Re_x = \frac{U_\infty x}{\nu} = \frac{10 \times 0.05}{10^{-5}}$

$= 5\times10^4 < 5\times10^5 \Rightarrow$ Laminar flow.

To find local shear stress, skin friction coefficient is used.

$$\therefore \tau_w\left(x = \frac{L}{2}\right) = \frac{1}{2} C_f \rho U_\infty^2$$

$$= \frac{1}{2} \times \frac{0.664}{\sqrt{5\times10^4}} \times 1.2\times10^2 = 0.18\,\text{Pa}$$

34. A metallic strip 250 mm wide and 10 mm thick is to be rolled using two steel rolls, each of 600 mm diameter. It is required to achieve 30 % reduction in cross-sectional area of the strip after rolling. If the plane strain flow stress of the strip material in the roll gap is 400 MPa, the roll separating force (in MN) is _______ (Rounded up to two decimal places).

34. Ans: 3.76 [Range: 3.00 to 4.00]

Sol: Given,

Initial thickness, H_o = 10 mm, H_1= (1 – 0.3) H_0 = 7 mm,

ΔH = 10 – 7 = 3 mm

Width of strip, b = 250 mm,

Roll radius, $R = 300$ mm, $\sigma_y = 400$ MPa

$\therefore$ Length of deformation zone, $L = \sqrt{R\,\Delta H} = \sqrt{300 \times 3} = 30$ mm

Assuming maximum reduction per pass

Coefficient of friction = $\mu = \text{Tan}(\beta) = \sqrt{\frac{\Delta H}{R}} = \sqrt{\frac{3}{300}} = 0.1$

Roll separating force $= \frac{2}{\sqrt{3}}\sigma_y (bL)\left[1 + \frac{\mu L}{4H}\right]$

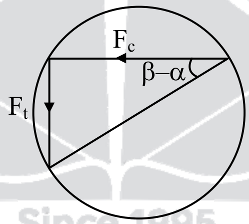
$$= \frac{2}{\sqrt{3}} 400(250 \times 30)\left[1 + \frac{0.1 \times 30}{4 \times 8.5}\right] = 3.76 \text{ MN}$$

35. In an orthogonal machining operation, the cutting tool used has 5 degrees rake angle and friction angle at the secondary zone is 32°. If the thrust force measured by two – component dynamometer is 750 N, the cutting force (in N) is ________ (Rounded upto two decimal places).

35. Ans: 1471.95 [Range: 1467.00 to 1477.00]

Sol: Constructing the merchant circle diagram

As clear from the diagram



$$\tan(\beta - \alpha) = \frac{F_t}{F_c}$$

$$\Rightarrow \tan(32 - 5) = \frac{750}{F_c}$$

$$\Rightarrow F_c = \frac{750}{\tan 27} = 1471.95$$

36. A cubical cavity of 100 mm side is made such a way that half of the cavity is in drag box. Height of the cope box is 100 mm and its area is 150 mm × 150 mm. If the densities of the sand and the metal poured in the cavity are 1600 kg/m^3 and 8000 kg/m^3 respectively, the minimum weight required to be placed on the cope box (in N) to prevent the lifting of cope box by molten metal is ________ (Rounded upto two decimals only).

36. Ans: 11.77 [Range: 11.00 to 12.30]

Sol: Given data:

A cubical casting cavity,

Side (a) = 100 mm

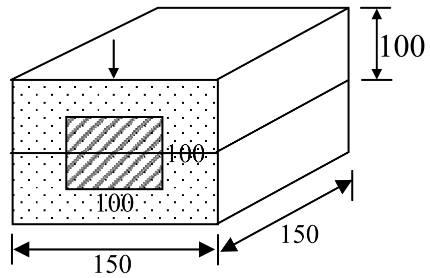
Density of sand = 1600 kg/m^3

Density of metal = 8000 kg/m^3

Weight of cope = volume of cope × density × g

$= [(0.15\times0.15\times0.1) - (0.1\times0.1\times0.05)]\times1600 \times9.81$

$= 27.468$ N



Metallostatic force of liquid metal on cope

= projected area of cubical cavity × Pressure

$= 0.1\times0.1\times0.05\times (8000\times9.81)$

$= 39.24$ N

$\text{Net B.F.} = (39.24 - 27.468) = 11.772\,\text{N}$

The minimum weight required to be placed on the cope box (in N) to prevent the lifting of cope box by molten metal is 11.77 N

37. In a spot welding process, the secondary voltage of the transformer is set as 5V and the timer for current passage is set as 0.2 sec. If the contact resistance between the sheets is 200 micro ohms and the total resistance of the circuit other than the interface resistance between the sheets is 100 micro ohms, the heat generated at the interface (in kJ) is ______ (Rounded up to one decimal only).

37. Ans: 11.1 [Range: 10.8 to 11.4]

Sol: Given data:

$V = 5V$

$T = 0.2$ Sec

$R_{contact} = 200\times10^{-6}\ \Omega$

R_{circut} (other than contact resistance) = $100\times10^{-6}\ \Omega$

$R_{total} = (100 + 200)\times10^{-6} = 300\times10^{-6}\ \Omega$

The heat generated at the interface (H) = $I^2 R \tau$

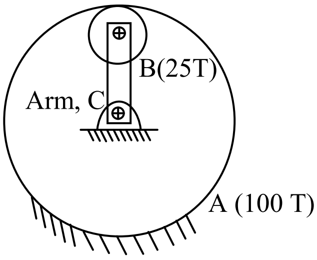
$$I = \frac{V}{R_{total}} = \frac{5}{300\times10^{-6}} = \frac{50000}{3} = 16{,}666.7\text{A}$$

$H = I^2 \times R_{contact} \times \tau$

$= (16{,}666.7)^2 \times 200 \times 10^{-6}\times0.2$

$= 11111.15\ \text{J} = 11.1\ \text{kJ}$

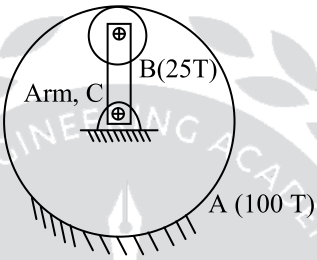
38. Epi-cyclic gear train shown in figure consists of a fixed gear 'A' with 100 teeth meshed internally with gear B having 25 teeth. The arm 'C' rotates at 10 rad/s clockwise and imparts 30 N-m of torque. The holding torque on fixed gear A (in N-m) is __________



38. Ans: 40 [Range: 39 to 41]

Sol: $N_A = 0$, $N_B = -30$ rad/sec, $N_C = 10$ rad/sec, $T_C = 30$ N-m

$$\frac{N_B - N_C}{N_A - N_C} = \frac{Z_A}{Z_B}$$



$$\frac{N_B - 10}{0 - 10} = \frac{100}{25} \Rightarrow N_B = -30$$

$$N_A T_A + N_B T_B + N_C T_C = 0$$

$$-30 \times T_B + 10 \times 30 = 0$$

$$\therefore T_B = 10 \text{ N-m}$$

$$T_A + T_B + T_C = 0$$

$$T_A + 10 + 30 = 0$$

$$\therefore T_A = -40 \text{ N-m}$$

39. In free vibration response of a damped system, the amplitude reduces to one tenth of its initial value after two cycles. The damping ratio of the system is ___________ (Rounded upto two decimals).

39. Ans: 0.18 [Range: 0.175 to 0.195]

Sol: $X_2 = \frac{X_0}{10}$ (after two cycles)

$$\frac{X_0}{X_2} = 10$$

$$\ell n \left|\frac{X_0}{X_2}\right| = 2\delta = \ell n \,|10|$$

$$\therefore\ \delta = 1.1513$$

But, $\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$

or $\xi = \sqrt{\frac{\delta^2}{4\pi^2 + \delta^2}}$

$$\therefore\quad \xi = 0.180234 \approx 0.18$$

40. In a bolted joint two flanges of combined stiffness 400 kN/mm are bolted by a bolt of stiffness 100 kN/mm. The pitch of the bolt is 2 mm. If the bolt is tightened by two revolutions, the tensile force (in kN) generated in the bolt is _______ .

40. Ans: 320 [Range: 320 to 320]

Sol: Let δ_P and δ_b be the compression in plate and elongation in bolt respectively.

The sum of deformation in the bolt and plate must be equal to distance traveled by the nut.

$$\delta_p + \delta_b = \delta$$

$$\frac{P}{k_p} + \frac{P}{k_b} = \delta$$

$$P = \frac{k_p k_b}{k_p + k_b} \times \delta = \frac{400 \times 100}{400 + 100} \times 4 = 320 \text{ kN}$$

41. In a plate clutch the coefficient of friction and maximum pressure intensity are 0.25 and 0.825 MPa respectively. The inner and outer diameters of the contact area are 225 mm and 300 mm respectively. The clamping force applied by the spring to hold the plates together for uniform wear theory is _______kN.

41. Ans: 21.9 [Range: 21 to 23]

Sol: $F = \int P\,dA$

$= \int \frac{c}{r} \times 2\pi r\,dr \quad [\because P \propto \frac{1}{r} \text{ for uniform wear}]$

$= 2\pi c\,(R_o - R_i)$

$= 2\pi\,(P_{max}\,R_i)\,(R_o - R_i) \quad [\because \text{ maximum pressure is present at inner radius}]$

$= 2\pi\,(0.825 \times 112.5) \times (150 - 112.5) = 21.9$ kN

42. For a transformer having linear power source characteristics, maximum power is obtained at 40 V and 150 A. The open circuit voltage and short circuit current are _____ and _____ respectively.

(A) 40 V and 150 A
(B) 80 V and 150 A
(C) 40 V and 300 A
(D) 80 V and 300 A

42. Ans: (D)

Sol: According to V-I characteristics of power source

$$V = V_0 - \frac{V_0}{I_S} I \Rightarrow \frac{V_0}{I_S} I = V_0 - V \Rightarrow \frac{I}{I_S} V_0 = V_0 (1 - \frac{V}{V_0})$$

$$\Rightarrow \frac{I}{I_S} = (1 - \frac{V}{V_0}) \Rightarrow \frac{I}{I_S} + \frac{V}{V_0} = 1 \text{ ---- (i)}$$

(Where, V_0 = Open Circuit Voltage, I_S = Short Circuit Current)

$$P = VI = V_0\left(1 - \frac{I}{I_S}\right) \times I$$

$$P = V_0\left(I - \frac{I^2}{I_S}\right)$$

For $P = P_{max}$; $\frac{\partial P}{\partial I} = 0$

$$\frac{\partial P}{\partial I} = V_0\left(1 - \frac{2I}{I_S}\right) = 0$$

$$I = \frac{I_s}{2} = 150\,A$$

I = 300 A

By substituting I_S value in equation (i), we get

$\Rightarrow V_0 = 80$ V

(***Shortcut method:*** V_0 should be greater than V and I_S should be greater than I, both are satisfied in D).

DISTRACTOR LOGIC :

DLOA : Incorrect option, if wrongly assumed/ calculated as

$$\frac{I}{I_S}+\frac{V}{V_0}=1$$

$$\frac{150}{300}+\frac{40}{V_0}=1$$

$$V_0 = 80V$$

$$I=\frac{I_S}{2}=150A$$

DLOB : Incorrect option, if misinterpreted as

$V = V_0$

$I = I_s$.

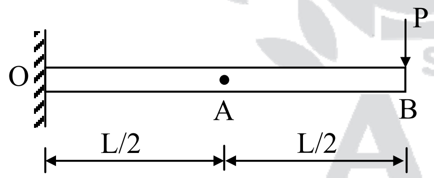
DLOC : Incorrect option, if misinterpreted as

$V = V_s$

$2I = I_s = 2 \times 150 = 300$ Amp

DLOD : Correct option (As explained above).

43. The cantilever beam of length 'L' and flexural rigidity EI carries a point load 'P' at its free end as shown in the figure below.

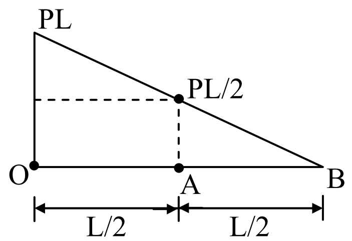


The deflection at point 'A' on the beam is

(A) $\frac{PL^3}{6\,EI}$ (B) $\frac{5\,PL^3}{24\,EI}$ (C) $\frac{5\,PL^3}{48\,EI}$ (D) $\frac{5\,PL^3}{6EI}$

43. Ans: (C)

Sol: The deflection at point 'A' can be found from moment area method as given below.



$\delta_{A/O} = \frac{1}{EI}$ (Moment of area of BMD between O and A about A)

$$= \frac{1}{EI}\left[\left(\frac{PL}{2}\times\frac{L}{2}\right)\times\left(\frac{L}{4}\right)+\left(\frac{1}{2}\times\frac{PL}{2}\times\frac{L}{2}\right)\times\left(\frac{2}{3}\times\frac{L}{2}\right)\right]$$

$$= \frac{PL^3}{EI}\left(\frac{1}{16}+\frac{1}{24}\right) = \frac{5PL^3}{48EI}$$

DISTRACTOR LOGIC :

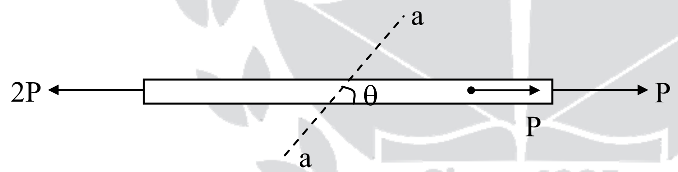
DLOA : If deflection of 'A' is considered as half of that of 'B' then option 'A' is obtained.

DLOB : If lengths $\frac{L}{2}$ and $\frac{2L}{3}$ are considered while calculating C.G. of rectangle and triangle instead of $\frac{L}{4}$ and $\frac{2}{3}\left(\frac{L}{2}\right)$ then option 'B' is obtained.

DLOC : Correct option.

DLOD : If total length of beam is considered (2L) instead of 'L' then option 'D' is obtained.

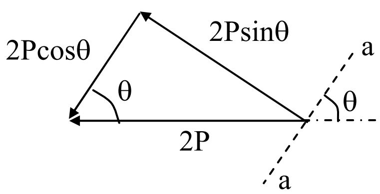
44. A bar of uniform cross-section 'A' carries concentrated loads as shown in the diagram below. The normal stress on the inclined plane a-a is



(A) $\frac{P}{A}\sin^2\theta$ (B) $\frac{2P}{A}\sin^2\theta$ (C) $\frac{P}{A}\sin 2\theta$ (D) $\frac{2P}{A}\cos^2\theta$

44. Ans: (B)

Sol: The force in section a-a is 2P which can be resolved into normal and tangential components as,



The resisting area along a-a is $\frac{A}{\sin\theta}$.

$$\sigma_n = \frac{\text{Normal force}}{\text{Resisting area}} = \frac{(2P\sin\theta)}{(A/\sin\theta)} = \frac{2P}{A}\sin^2\theta$$

DISTRACTOR LOGIC :

DLOA : If force 'P' is considered instead of '2P' then option 'A' is obtained.

DLOB : Correct option

DLOC : If force 'P' is considered instead of '2P' and tangential component is calculated instead of normal component then option 'C' is obtained.

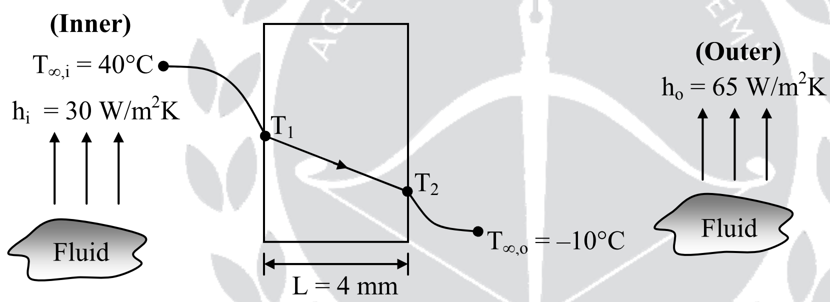
DLOD : If tangential component is considered or angle '90 – θ' is considered instead of θ then option 'D' is obtained.

45. The rear window of an automobile is defogged by passing warm air over its inner surface. The warm air is at $T_{\infty,i}$ = 40°C and the corresponding convection coefficient is h_i = 30 W/m^2-K. The outside ambient air temperature is $T_{\infty,o}$ = –10°C and the associated convection coefficient is h_o = 65 W/m^2-K. The outer surface temperature of 4 mm thick window glass (k = 1.2 W/m-K) is

(A) 4.77°C (B) 18.87°C (C) 7.94°C (D) 20.76°C

45. Ans: (A)

Sol:



$$\text{Heat transfer rate} = \frac{T_{\infty,i} - T_{\infty,o}}{\frac{1}{h_i A} + \frac{L}{k.A} + \frac{1}{h_o A}} = \frac{T_2 - T_{\infty,o}}{\frac{1}{h_o.A}} \text{------------(1)}$$

$$\Rightarrow \quad \frac{40-(-10)}{\frac{1}{30}+\frac{0.004}{1.2}+\frac{1}{65}} = \frac{T_2-(-10)}{\frac{1}{65}}$$

$$\frac{50}{0.052} = (T_2 + 10)\times 65$$

$$T_2 = 4.77°C$$

DISTRACTOR LOGIC:

DLOA : Correct option

DLOB : Incorrectly taken $T_{\infty,o}$ = 10°C instead of –10°C in equation (1)

DLOC : Inner surface temperature is calculated instead of outer surface.

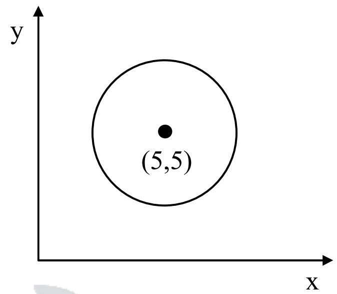
DLOD : Inner surface temperature is calculated instead of outer surface by using $T_{\infty,o}$ = 10°C instead of -10°C.

46. The stream function for a two dimensional incompressible flow is given by $\psi = Axy + Ay^2$ (Where $A = 1s^{-1}$). The magnitude of circulation about a circle of unit radius with centre at point (5, 5) is

(A) π (B) 2π (C) 4π (D) 50π

46. Ans: (B)

Sol: $u = \frac{-\partial\psi}{\partial y} = -(Ax + 2Ay) = -(x + 2y)$



$v = \frac{\partial\psi}{\partial x} = Ay = y$

$\omega_z = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) = \frac{1}{2}(0 - (-2))$

The angular velocity is constant over entire flow field

The circulation (Γ) is given by

$$\Gamma = \oint \vec{v}.\vec{ds} = \iint_A 2\vec{\omega}\,\overrightarrow{dA} = \iint_A 2(1)dA = 2\iint_A dA = 2A \Rightarrow 2\times\pi\,(1)^2 = 2\pi$$

DISTRACTOR LOGIC:

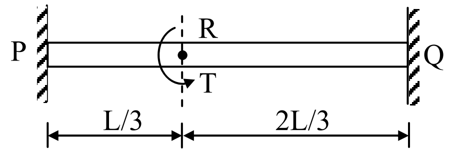
DLOA : If w is considered instead of 2ω then option 'A' is obtained

DLOB : Correct option

DLOC : If factor of 1/2 is ignored in the definition of ω_z then option 'C' is obtained.

DLOD : If radius of circle is taken as '5' instead of '1' then option 'D' is obtained.

47. A circular bar of length 'L', polar moment of inertia 'J' and modulus of rigidity 'G' carries a torque 'T' at a distance L/3 from one end. The bar is fixed at both ends P and Q as shown in the figure below.



The angle of twist (θ) of the point of application of the torque with respect to fixed end in radians is

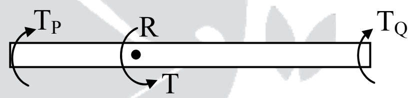
(A) $\frac{4TL}{9GJ}$ (B) $\frac{2TL}{9GJ}$

(C) $\frac{TL}{9GJ}$ (D) $\frac{TL}{3GJ}$

47. Ans: (B)

Sol: The torque reactions T_P and T_Q are opposite to the applied torque.

$\therefore\ T_P + T_Q = T$-------(1)



The angle of twist of point 'R' is same with respect to both the ends.

i.e. $\theta_{RP} = \theta_{RQ}$

$$\therefore\ \frac{T_P(L/3)}{GJ} = \frac{T_R(2L/3)}{GJ}$$

$\therefore\ T_P = 2T_Q$

From equation (1), $T_Q = \frac{T}{3}$ and $T_P = \frac{2T}{3}$

Thus, $$\theta_{RP} = \frac{(2T/3)(L/3)}{GJ} = \frac{2}{9}\frac{TL}{GJ}$$

DISTRACTOR LOGIC :

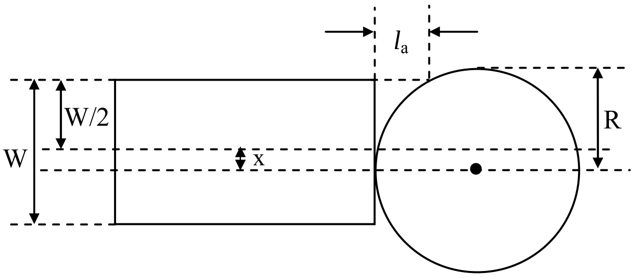
DLOA : If 2L/3 length is considered instead of L/3 then option 'A' is obtained.

DLOB : Correct option.

DLOC : If T/3 torque is considered instead of 2T/3 then option 'B' is obtained.

DLOD : If T torque is considered instead of 2T/3 then option 'D' is obtained.

48. A schematic diagram of face milling operation is shown in the figure.



If R is the cutter radius, 'W' is the width of the workpiece and 'x' is the offset, then the length of approach (ℓ_a) is expressed as

(A) $R-\sqrt{R^2+\left(\frac{W}{2}+x\right)^2}$

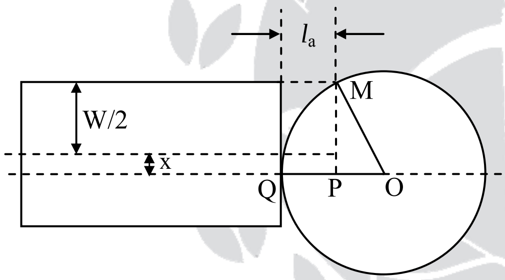
(B) $R-\sqrt{R^2-\left(\frac{W}{2}+x\right)^2}$

(C) $R-\sqrt{R^2-\left(\frac{W}{2}-x\right)^2}$

(D) $R+\sqrt{R^2-\left(\frac{W}{2}-x\right)^2}$

48. Ans: (B)

Sol:



$\ell_a = PQ = OQ - OP$

$= R-\sqrt{OM^2-MP^2}$ (Applying Pythagoras theorem)

$\ell_a = R-\sqrt{R^2-\left(\frac{W}{2}+x\right)^2}$

DISTRACTOR LOGIC :

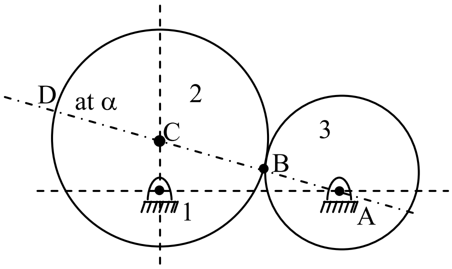
DLOA : Applying Pythagoras theorem incorrectly.

DLOB : Correct.

DLOC : Offset 'x' can be wrongly subtracted from half – width.

DLOD : Wrong identification of approach length ℓ_a

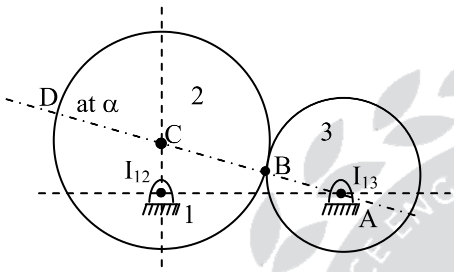
49. Two circular discs are connected as shown in figure. The instantaneous centre between the discs 2 and 3 is located at



(A) A (B) B (C) Either A or B (D) cannot be predicted

49. Ans: (A)

Sol:



Disc ‘1’ does not rotate about its C.G.

The motion at ‘B’ is rolling as well as Sliding.

Common normal is locus of I_{23} and it is line joining both the disc centres.

By Kennedy’s Theorem I_{23} is located on line joining I_{12} and I_{13}.

Both the above mentioned lines intersect at the centre of disc 3 i.e at A.

<u>DISTRACTOR LOGIC :</u>

DLOA : Correct option

DLOB : When we assume both the discs running about centre of mass then B is instantaneous centre of mass for system.

DLOC : Lines intersect at disc centre 3 i.e., A . So, wrong option

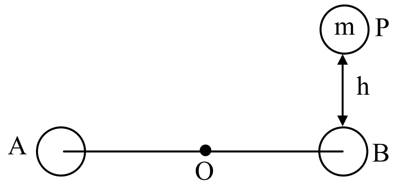
DLOD : Wrong option

50. Two small balls A and B, each of mass m, are joined rigidly to the ends of a light rod of length L. The rod is clamped at the centre in such a way that it can rotate freely about a horizontal axis through the clamp. The system is kept at rest in the horizontal position. A particle P of the same mass m is dropped from a height h on the ball B. The particle collides with B and sticks to it. The angular speed of system just after the collision is

(A) $\frac{\sqrt{8gh}}{\sqrt{3}L}$ (B) $\frac{\sqrt{8gh}}{3L}$ (C) $\frac{\sqrt{2gh}}{L}$ (D) $\frac{8\sqrt{gh}}{3L}$

50. Ans: (B)

Sol:



Since, there is no external torque acting about the clamp 'O', so the angular momentum of the system (just before and after particle sticks to ball B) remains conserved about point O.

Just before striking the ball B, the particle has speed, $V = \sqrt{2gh}$

Initial angular momentum = $m \times \sqrt{2gh} \times \frac{L}{2}$

Final angular momentum = $I \times \omega = 3 \times m \times \left(\frac{L}{2}\right)^2 \times \omega$

$$m \times \sqrt{2gh} \times \frac{L}{2} = 3 \times m \times \left(\frac{L}{2}\right)^2 \times \omega$$

$$\omega = \frac{\sqrt{8gh}}{3L}$$

DISTRACTOR LOGIC :

DLOA : If we use conservation of mechanical energy then,

$$mgh = \frac{1}{2} I\omega^2$$

$$\omega = \frac{\sqrt{8gh}}{\sqrt{3}L}$$

DLOB : Correct option

DLOC : If we use conservation of linear momentum

$$m \times \sqrt{2gh} = 2mv$$

$$v = \frac{\sqrt{2gh}}{L} = \omega \times \frac{L}{2}$$

$$\omega = \frac{\sqrt{2gh}}{L}$$

DLOD : Wrong calculation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6 CE Rishabh
6 E&T
6 EE
6 ME
7 E&T
7 ME
8 CE Aditya
8 E&T
8 EE
9 CE
9 E&T
9 EE
9 ME
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14 E&T
14 EE
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15 EE
15 ME
16 E&T MADHUR GOEL
16 EE
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19 EE
20 E&T
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20 ME
21 CE Jay Karan
21 EE
22 E&T
22 EE
23 EE
23 ME
24 CE
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25 E&T
25 EE
25 EE
26 E&T
26 EE
27 CE
28 E&T
28 EE
28 ME
28 ME
29 EE
30 E&T
30 EE
31 ME Umakanth
32 E&T
32 EE
33 CE
34 E&T Satpal
34 EE
35 EE
36 EE
37 CE
37 E&T
38 E&T
38 EE
39 E&T
39 EE
39 ME Amit
40 ME Ujjwal
TOTAL SELECTIONS 188
CE 82
ME 42
EE 35
E&T 29

51. If 20 kJ of heat is added to Carnot cycle at temperature of 100°P (where °P is an arbitrary unit of temperature) and 14.6 kJ is rejected at 0°P, the location of absolute zero on the scale is [Assume linear relation between temperature in Kelvin (K) and the arbitrary unit (°P)].

(A) –273.15 (B) –273.16 (C) –270.37 (D) +273.15

51. Ans: (C)

Sol: Consider an absolute thermodynamic temperature T.

Such that for Carnot cycle

$\Rightarrow \dfrac{Q_1}{Q_2} = \dfrac{T_1}{T_2}$ [where Q_1 = 20 kJ, Q_2 = 14.6]

$\Rightarrow \dfrac{20}{14.6} = \dfrac{T_1}{T_2}$

$\because$ T = (at + b)

Let, $T_1 = (at_1 + b)$, $T_2 = at_2 + b$

$\therefore$ $T_1 = at_1 + b$, $T_2 = at_2 + b$

$\therefore$ $T_1 = a \times 100 + b$, $T_2 = a \times 0 + b = b$

$\Rightarrow \dfrac{20}{14.6} = \left(\dfrac{100a + b}{b}\right)$

$20b = 14.6 \times 100a + 14.6b$

$\therefore$ b = 270.37a

At absolute zero, T = 0

$\therefore$ 0 = at + b

$\therefore$ 0 = at + 270.37a

$\therefore$ t = –270.37°P

<u>DISTRACTOR LOGIC :</u>

DLOA : Absolute zero in Kelvin scale is equivalent to –273.15°P in celsius scale. This option is given to confuse the student.

DLOB : This option is incorrect and is given to confuse the student. –273.16

In Kelvin scale absolute zero is equal to –273.16°P in celcius scale. So option B is also wrong.

DLOC : Explained in the above solution.

DLOD : This option is given to confuse the student. Absolute zero in Celsius scale cannot be 273.15°P, it must be below 0°P.

52. The system of linear equations

$$x_1 - 3x_2 + 2x_3 = 5$$
$$x_1 - x_3 = -1$$
$$x_1 - 2x_2 + x_3 = 5 \text{ has}$$

(A) exactly two solutions (B) no solution
(C) a unique solution (D) many solutions

52. Ans: (B)

Sol: Consider the augmented matrix of the given system

$$[A|B] = \left[\begin{array}{ccc|c} 1 & -3 & 2 & 5 \\ 1 & 0 & -1 & -1 \\ 1 & -2 & 1 & 5 \end{array}\right]$$

$$R_2 \to R_2 - R_1, \quad R_3 \to R_3 - R_1 \quad \sim \left[\begin{array}{ccc|c} 1 & -3 & 2 & 5 \\ 0 & 3 & -3 & -6 \\ 0 & 1 & -1 & 0 \end{array}\right]$$

$$R_3 \to 3R_3 - R_2 \quad \sim \left[\begin{array}{ccc|c} 1 & -3 & 2 & 5 \\ 0 & 3 & -3 & -6 \\ 0 & 0 & 0 & 6 \end{array}\right]$$

Here, $\rho(A) = 2$ and $\rho(A|B) = 3$

$\therefore$ The given system is inconsistent and has no solution

53. The directional derivative of $\phi(x, y, z) = xy^2z + 4yz^2$ at the point P(1, 2, –1) along $\bar{i} - 2\bar{j} + \bar{k}$ is ___.

(A) –16 (B) $\frac{1}{\sqrt{6}}$ (C) $\frac{-16}{\sqrt{6}}$ (D) $\frac{16}{\sqrt{7}}$

53. Ans: (C)

Sol: Given that $\phi(x, y, z) = xy^2z + 4yz^2$

Let $\bar{a} = \bar{i} - 2\bar{j} + \bar{k}$ & P = (1, 2, –1)

Now $\nabla\phi = \text{grad } \phi = \bar{i}\frac{\partial\phi}{\partial x} + \bar{j}\frac{\partial\phi}{\partial y} + \bar{k}\frac{\partial\phi}{\partial x}$

$\Rightarrow \nabla\phi = \bar{i}\left(y^2z\right) + \bar{j}\left(2xyz + 4z^2\right) + \bar{k}\left(xy^2 + 8\,yz\right)$

$\Rightarrow (\nabla\phi)_P = (-4)\ \bar{i} + (0)\ \bar{j} + (-12)\ \bar{k}$

Now the directional derivative of the function $\phi(x, y, z)$ in the direction of a vector $\bar{a}$ at the point P

$$= (\nabla\phi)_P \cdot \frac{\bar{a}}{|\bar{a}|}$$

$$= \left((-4)\bar{i} + (0)\bar{j} + (-12)\bar{k}\right) \cdot \frac{\left(\bar{i} - 2\bar{j} + \bar{k}\right)}{\sqrt{(1)^2 + (-2)^2 + (1)^2}}$$

$$= \frac{(-4)(1) + (0)(-2) + (-12)(1)}{\sqrt{1+4+1}}$$

$$= \frac{-16}{\sqrt{6}}$$

54. The particular integral of $2x^2\frac{d^2y}{dx^2} + 3x\frac{dy}{dx} - 3y = x^3$ is ________.

(A) $\frac{x^3}{6}$ (B) $\frac{x^3}{12}$ (C) $\frac{x^3}{16}$ (D) $\frac{x^3}{18}$

54. Ans: (D)

Sol: The given Euler-Cauchy's form can be converted to

$2D(D-1)y + 3Dy - 3y = e^{3z}$ (where $D = \frac{d}{dz}$, $x = e^z$ & $z = \log x$)

$(2D^2 + D - 3)y = e^{3z}$

$$\therefore\ y_P = \frac{e^{3z}}{\left(2D^2 + D - 3\right)}$$

$$= \frac{e^{3z}}{(2D+3)(D-1)} = \frac{e^{3z}}{(6+3)(3-1)} = \frac{e^{3z}}{18} = \frac{x^3}{18}$$

55. A person goes to office either by car, scooter, bus or train, the probability of which being $\frac{1}{7}, \frac{3}{7}, \frac{2}{7}$ and $\frac{1}{7}$ respectively. Probability that he reaches office late, if he takes car, scooter, bus or train are $\frac{2}{9}, \frac{1}{9}, \frac{4}{9}$ and $\frac{1}{9}$ respectively. Given that he reached office in time, then the probability that he travelled by car is

(A) $\frac{1}{5}$ (B) $\frac{1}{6}$ (C) $\frac{1}{7}$ (D) $\frac{1}{8}$

55. Ans: (C)

Sol: $P(C) = \frac{1}{7}$, $P(S) = \frac{3}{7}$, $P(B) = \frac{2}{7}$, $P(T) = \frac{1}{7}$

Let E be the event that he reaches office in time.

$$P(E \mid C) = \frac{7}{9}, P(E \mid S) = \frac{8}{9}$$

$$P(E \mid B) = \frac{5}{9}; P(E \mid T) = \frac{8}{9}$$

$$P(C \mid E) = \frac{\frac{1}{7} \times \frac{7}{9}}{\left(\frac{1}{7} \times \frac{7}{9}\right) + \left(\frac{3}{7} \times \frac{8}{9}\right) + \left(\frac{2}{7} \times \frac{5}{9}\right) + \left(\frac{1}{7} \times \frac{8}{9}\right)} = \frac{1}{7}$$

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HYDERABAD - Kukatpally	ESE + GATE + PSUs – 2019	Evening Batch	19th January 2018
Delhi	GATE + PSUs – 2019	Weekend Batch	13th & 27th January 2018
Delhi	GATE + PSUs – 2019	Regular Batch (Evening)	24th February 2018
Delhi	ESE + GATE + PSUs – 2019	Weekend Batch	13th & 27th January 2018
Delhi	ESE + GATE + PSUs – 2019	Regular Batch (Evening)	24th February 2018
Bhopal	GATE + PSUs – 2019	Morning & EveningBatch	29th January 2018
Bhopal	GATE + PSUs – 2020	Morning & EveningBatch	29th January 2018
Bhopal	ESE+GATE + PSUs – 2019	Morning & Evening Batch	29th January 2018
Bhopal	ESE+GATE + PSUs – 2020	Morning & Evening Batch	29th January 2018
Pune	GATE + PSUs – 2019	Weekend Batch	20th January 2018
Pune	GATE + PSUs – 2019	Evening Batch	22nd January 2018
Pune	ESE+GATE + PSUs – 2020	Weekend Batch	20th January 2018
Bengaluru	GATE + PSUs – 2019	Weekend Batch	20th January 2018
Vijayawada	GATE + PSUs – 2019&20	Weekend Batch	21st January 2018
Kolkata	GATE + PSUs – 2019	Weekend Batch	20th January 2018
Kolkata	GATE + PSUs – 2020	Weekend Batch	20th January 2018