gradeup

GATE 2020
Mechanical Engineering

Mega Mock Challenge
(02 Jan-03 Jan 2020)

Questions & Solutions

1. **Direction:** In the given question, four words are given of which two are most nearly the same or opposite in meaning. Find the two words and indicate your answer by marking the option which represents the correct combination.

A) Diligent B) Adorable
C) Meticulous D) Prominent

A. B-D B. A-C
C. A-B D. A-D

Ans. B

Sol. The meanings of the words are:
Diligent: having or showing care and conscientiousness in one's work or duties.
Adorable: inspiring great affection or delight.
Meticulous: showing great attention to detail; very careful and precise.
Prominent: important; famous.
Hence, **option B** is the correct answer.

2. **Direction:** A statement with one blank is given below. Choose the set of words from the given options which can be used to fill the given blank.
Despite almost ubiquitous scepticism, the electoral bonds have prevailed and, that too, almost solely ________ rhetorical claims of "transparency of political funding system," "clean money," and "donor's anonymity."
i. with the backing of the ruling government's
ii. based on the endorsement derived from the political party at power's
iii. backed by the political party at power's

A. Only i B. Only ii
C. Only iii D. Both i and ii

Ans. D

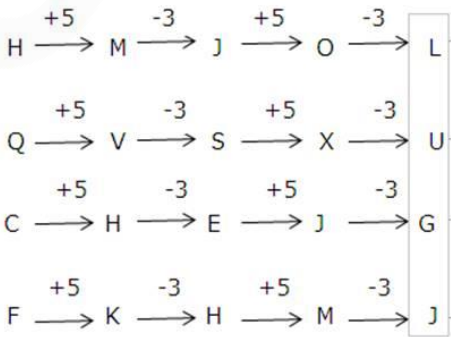
Sol. The given sentence talks about the prevailing nature of 'electoral bonds' in spite of concerns and doubts regarding the same. The sentence goes on to explain that this is occurring because of rhetorical claims by someone. From the options it is clear that the ruling part is responsible for these 'rhetorical claims'.
Option i – 'backing' means help or support and has been used in conjunction with the correct tense format of the sentence.
Option ii – 'endorsement' also means help or support and it tallies with the sentence structure.
Option iii – although 'backed' has been used it is in the incorrect tense form. This makes it incorrect.
Thus, option D is the correct answer.

3. Which letter—cluster will replace the question mark (?) in the following series?
HQCF, MVHK, JSEH, OXLM, ?

A. FTRD B. LUGJ
C. MKOP D. SWQ

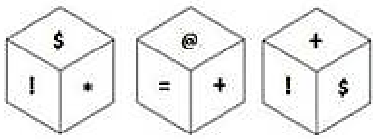
Ans. B

Sol. Pattern is-



Hence, the correct answer is option B.

4. Three different positions of the same dice are shown. Which symbol will be on the face opposite to the one having '*'?



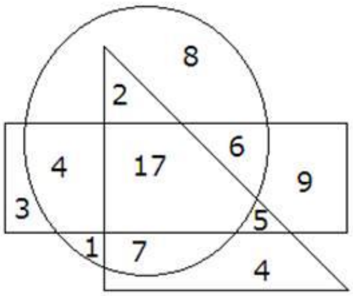
A. + B. !
C. $ D. @

Ans. A

Sol. Pick out the dices in which one symbol is common , after that arrange them in ACW or CW direction.

In II and III '+' is common
+ = @
* + ! $
Interchange the missing symbol '*' with repeated symbol '+'
Hence, option (A) is the correct answer.

5. In the following diagram, the triangle represents 'Dentists', the circle represents 'Professors' and the rectangle represents 'Doctors'. The numbers in different segments show the number of persons.

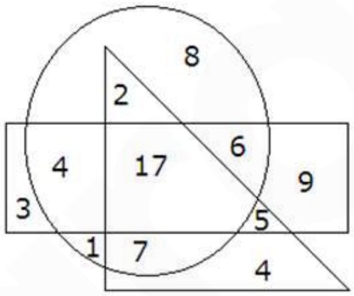


How many professors are dentists but not doctors?

A. 17 B. 9
C. 15 D. 13

Ans. B

Sol. Given diagram is-



circle represents Professors
rectangle represents Doctors
triangle represents Dentists
No. of professors who are dentists but not doctors=2+7=9
Hence, the correct answer is option B.

6. In the following question, some statements followed by some conclusions are given. Taking the given statements to be true even if they seem to be at variance from commonly known facts, read all the conclusions and then decide which of the given conclusions logically follows the given statements.

Statement:
Parents must understand that their child cannot attain excellence on his own. He needs their support. They must thus be open to help him at various steps rather than merely setting high expectations.

Conclusion:
I. Ideal students are not born ideal or perfect. They are nurtured to become ideal by their educators. The environment at home has a great impact on the way a student performs in school.
II. The life of an ideal student may seem tough from a distance. However, it is actually much more sorted as compared to those who procrastinate and do not give complete attention to their studies.

A. If only conclusion I follows
B. If only conclusion II follows
C. If both I and II conclusion follow
D. If neither I nor II conclusion follows

Ans. A

Sol. Conclusion I follows, based on the given statement a major component in the making of an Ideal student is described that it takes efforts not only from the students but also from the educators(Teachers and Parents)
Conclusion II is a correct statement that is the hard work and struggle that it takes to become an ideal student but it cannot be the conclusion of the given statement.

7. **Direction:** Each question below is followed by two statements I and II. You have to determine whether the data given in the statement is sufficient for answering the question. You should use the data and your knowledge of Mathematics to choose the best possible answer.

A man deposited Rs. 'x' in bank which gives simple interest at the rate of 8% p.a. Find the value of 'x'.
Statement I: After 3 years, amount received by him is Rs. (x + 672).
Statement II: Interest earned by him after 3 years is 24% of the amount deposited by him.
A. If the data in Statement I alone are sufficient to answer the question, while the data in Statement II alone are not sufficient to answer the question.
B. If the data in Statement II alone are sufficient to answer the question, while the data in Statement I alone are not sufficient to answer the question.
C. If the data either in Statement I or in Statement II alone are sufficient to answer the question.
D. If the data in both Statements I and II together are necessary to answer the question.

Ans. A

Sol. Statement I:
Simple interest earned by him
$= x + 672 - x = Rs. 672$
So, $672 = \frac{x \times 8 \times 3}{100}$
$x = Rs. 2800$
So, statement I alone is sufficient to answer the question.
Statement II:
We have to calculate principal(x) but we are not given interest since it is also in form of x. Hence, there are 2 unknowns.
Statement II alone is not sufficient to answer the question.
Thus, the data in Statement I alone are sufficient to answer the question, while the data in Statement II alone are not sufficient to answer the question.
So option (A) is the correct answer.

8. The given pie chart shows the breakup of total number of the employees of a company working in different offices (A, B, C, D and E).
Total no. of employees = 2400

What is the number of offices in which the number of employees of the company is between 350 and 650?
A. 3 B. 4
C. 2 D. 1

Ans. A

Sol. Total no. of Employees (360°) = 2400
No. of employees in office A(126°)
$= \frac{2400}{360} \times 126 = 840$
No. of employees in office B(18°)
$= \frac{2400}{360} \times 18 = 120$
No. of employees in office C(54°)
$= \frac{2400}{360} \times 54 = 360$
No. of employees in office D(90°)
$= \frac{2400}{360} \times 90 = 600$
No. of employees in office E(72°)
$= \frac{2400}{360} \times 72 = 480$
Number of offices in which the number of employees of the company is between 350 and 650 = 3

9. Find the numbers a, b, c between 2 and 18 such that
I. their sum is 25,
II. the numbers 2, a, b are consecutive terms of an A.P. and
III. The numbers b, c, 18 are consecutive terms of a G.P.
A. a=5, b=8, c=12
B. a=7, b=8, c=12
C. a=5, b=9, c=11
D. a=7, b=5, c=11

Ans. A

Sol. We have a + b + c = 25 ...(i)

2, a, b are in A.P. ⇒ 2a = 2 + b ...(ii)

b, c, 18 are in G.P. ⇒ 18b = c2 ...(iii)

Substituting for a and b in (1), using relations (2) and (3), we get

$\Rightarrow 1+\frac{b}{2}+\frac{c^2}{18}+c=25$

⇒ $c^2 + 12c - 288 = 0$

⇒ (c − 12) (c + 24) = 0

⇒ C= 12 or c= -24

Since the numbers lie between 2 & 18,

We take c=12

⇒ a + b = 13

⇒ a + 2a -2 = 13

⇒ b=8, a=5

10. **Statements:**

All lions are ducks.

No duck is a horse.

All horses are fruits.

Conclusions:

I. No lion is a horse.

II. Some fruits are horses.

III. Some ducks are lions.

IV. Some lions are horses.

A. Only either I or II and III & IV follow

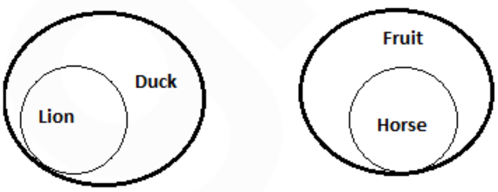
B. Only either I or IV and both II and III follow

C. Only either I or IV and II follow

D. Only Conclusion I & II and III follow

Ans. D

Sol.



We use elimination to find an exception to the generality of the question. Thus we prove they are not implied. The diagram above satisfy all the above statement but contradict with the conclusion (iv). Since we found an exception, the conclusion is not true in every case. Thus it is not implied.

We can draw many scenarios that satisfy the statements using Venn diagram & check for the validity of the conclusions.

Conclusions (i), (ii), (iii) hold good for every case so they are implied.

11. If a Metal Inert Gas welding, two stainless steel workpieces are joined with electrode diameter of 2.4 mm, wire feed rate of 3.2 m/min and total area of weld bead of 40 mm2, then the welding speed used in the welding process will be ________ mm/sec.

Sol. Melting rate of electrode

$=\frac{\pi}{4}\times 2.4^2\times 3200 = 14476.45\ mm^3/min$

Melting rate of electrode = filling rate of weld bead

14476.45 = area of weld bead × velocity of welding

14476.45 = 40 × V

⇒ V = 14476.45/40 = 361.9 mm/min

$\text{Welding speed (mm/sec)}=\frac{361.9}{60}$

= 6.03 mm/sec

12. In a vapour compression cycle, the enthalpy at the inlet to the compressor is 210 kJ/ kg and at that of the exit of the compressor is 230 kJ/ kg. If the enthalpy at the exit of the condenser is 100 kJ/kg, calculate the COP of the system.

A. 9.3 B. 3.4

C. 6.2 D. 5.5

Ans. D

Sol. We know that, COP = $\frac{h_1-h_3}{h_2-h_1}$

So, COP = $\frac{210-100}{230-210}$ = 5.5

So, COP = 5.5

13. Which micrometer is used for measuring the span between the teeth of a gear?

A. Blade micrometer

B. Screw thread micrometer

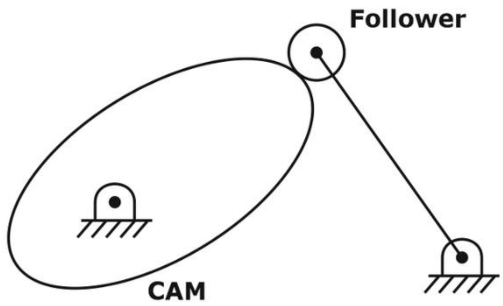
C. Disc micrometer

D. Dial micrometer

Ans. C

Sol. Disc micrometer is employed for measurement span between the teeth of a gear.

14. Find DOF of the given cam and follower mechanism:



A. 1 B. 2
C. 3 D. 0

Ans. A

Sol. Number of links, n = 4
Number of lower pairs, j = 3
Number of higher pairs, h = 1
DOF = 3(n - 1) -2j -h = 3(4 − 1) - 2×3 − 1 = 2
Redundant motion = 1 (between CAM and Follower)
So, Final DOF= 2-1 = 1

15. Which of the following is not a characteristics of martensitic transformation :-
A. Diffusionless
B. Change in composition
C. Change in crystal structure
D. Function of temperature and not of time

Ans. B

Sol.

Austenite (γ) ⟶ Martensite (α')
FCC BCT (Body Centered Tetragonal)
0.8% C 0.8% C

Charateristics of Martensitic Transformation:
*No change in composition
*Change in crystal structure
*Diffusionless
*Function of temperature and not of time
*Shear deformation
*Shape change involves large strains or considerable strain energy
So option (b) is the correct.

16. The value of integral $\oint_c \frac{\sin^2 z}{\left(z-\frac{\pi}{6}\right)^3} dz$, where C is the circle |z| = 1, will be
A. 2πi B. −2πi
C. −πi D. πi

Ans. D

Sol. There are three poles
at $z = \frac{\pi}{6} = 0.523$ lies inside the circle |z| = 1
So,

$$\oint_c \frac{\sin^2 z}{\left(z-\frac{\pi}{6}\right)^3} dz = \frac{2\pi i}{2!}\left(\frac{d^2}{dz^2}(\sin^2 z)\right)\Bigg|_{z=\frac{\pi}{6}}$$

$$= \pi i(2\cos 2z)\Big|_{z=\frac{\pi}{6}} = 2\pi i\cos(\pi/3) = \pi i$$

17. A journal bearing of 100 mm length and 50 mm diameter carrying load of 5 kN at 1200 rpm. Viscosity of lubricant used is 25 mPa-S. If radial clearance is 0.05 mm then, Sommerfield number will be:
A. 0.120 B. 0.125
C. 0.130 D. 0.145

Ans. B

Sol. Z= 25×10^{-3} Pa-S
n = 1200 rpm = 20rps
Pressure, p = 5000/(100×50) = 1 MPa = 10^6 Pa
Diametrical clearance, c = 2 *radial clearance = 0.1 mm
D = 50 mm
Sommerfield number,

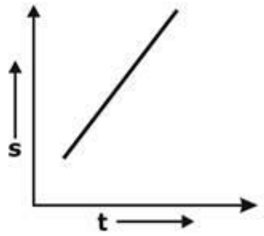
$$S = \frac{Zn}{p}\left(\frac{D}{c}\right)^2$$

$$s = \frac{25\times10^{-3}\times20}{10^6}\left(\frac{50}{0.1}\right)^2$$

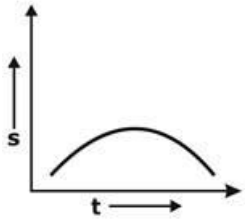
S = 0.125

18. Which of the following graph represents the uniform motion?

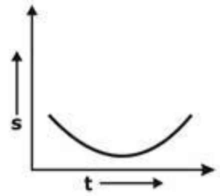
A.



B.



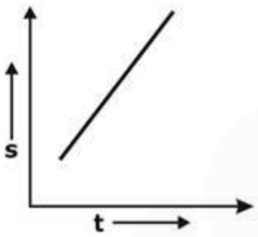
C.



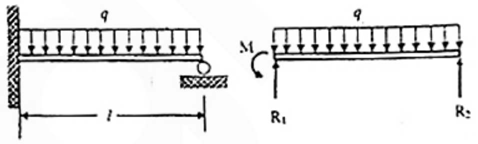
D. None of these

Ans. A

Sol. Uniform motion means uniform velocity or constant slope of s-t graph.
So the given option A will be correct option



19. A uniformly loaded propped cantilever beam and its free body diagram are shown below. The reactions are



A. $R_1 = \frac{5ql}{8}, R_2 = \frac{3ql}{8}, M = \frac{ql^2}{8}$

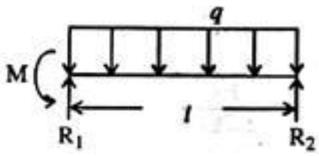
B. $R_1 = \frac{3ql}{8}, R_2 = \frac{5ql}{8}, M = \frac{ql^2}{8}$

C. $R_1 = \frac{5ql}{8}, R_2 = \frac{3ql}{8}, M = 0$

D. $R_1 = \frac{3ql}{8}, R_2 = \frac{5ql}{8}, M = 0$

Ans. A

Sol.



Since $R_1 + R_2 = ql$ . . . (i)

Moment about (i), $R_2 l + M$

$- \frac{ql^2}{2} = 0$ . . . (ii)

Moment about (ii), $R_1 l$

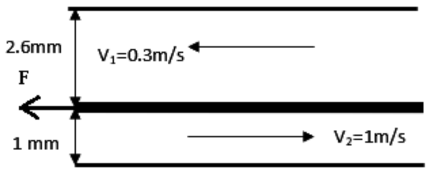
$- \frac{ql^2}{2} - M = 0$ . . . (iii)

$R_2 = 3ql/8$ by equating the deflection by uniformaly distributed load and point reaction R_2

Solving equation (i), (ii) and (iii) we get

$R_1 = \frac{5ql}{8}, R_2 = \frac{3ql}{8}$ and $M = \frac{ql^2}{8}$

20. A thin plate of 20cmX20cm is kept horizontal between two plates, one is 2.6mm above it and another is 1mm below it. An oil of viscosity 0.027 Pa.s is kept on both side is flowing in different direction as shown in the figure. Magnitude of horizontal force required to hold the plate in a fixed position is



Sol. Let F_{s1} is the shear force acting by the top fluid and F_{s2} is the shear force acting by the lower flowing fluid.

$$F + F_{S_1} = F_{S_2}$$

$$F + \tau_{S_1} \times A = \tau_{S_2} \times A$$

$$F = (\tau_{S_2} - \tau_{S_1}) \times A$$

$$F = \left(\mu \frac{V_2}{y_2} - \mu \frac{V_1}{y_1}\right) \times A$$

$$F = \left(\frac{1}{1 \times 10^{-3}} - \frac{0.3}{2.6 \times 10^{-3}}\right) \times 0.027 \times (0.2 \times 0.2)$$

$$F = 0.955 N$$

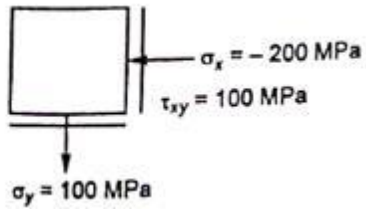
21. The state of plane-stress at a point is given by $\sigma_x = -200$MPa, $\sigma_y = 100$MPa and $\tau_{xy} = 100$MPa. the maximum shear stress in MPa is

A. 111.8 B. 150.1

C. 180.3 D. 223.6

Ans. C

Sol.



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

$$= \sqrt{\left(\frac{-200-100}{2}\right)^2 + 100^2}$$

$$= \sqrt{(-150)^2 + (100)^2} = 180.27\ MPa$$

22. The velocity field in a fluid medium is given by $V = 2xy\,\hat{i} + 2xy^2\,\hat{j} + 3zt\,\hat{k}$. Find the magnitude of rotational velocity vector at (2, 1, 1) and t = 2.

Sol.

rotation velocity vector $= w_x\hat{i} + w_y\hat{j} + w_z\hat{k}$

$$w = \frac{1}{2}\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ w_x & w_y & w_z \end{vmatrix} = \frac{1}{2}\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2xy & 2xy^2 & 32t \end{vmatrix}$$

$$w = \frac{1}{2}\left[(0-0)\hat{i} - (0-0)\hat{j} + (2y^2 - 2x)\hat{k}\right]$$

$$w = \frac{1}{2}\left[2y^2 - 2x\right]\hat{k}$$

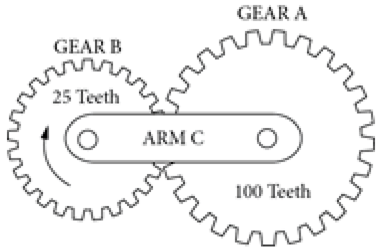
At (2, 1, 1)

$$w = \frac{1}{2}[2-4]\hat{h} = \frac{-2}{2}\hat{h}$$

$\boxed{w = -\hat{k}}$

$\boxed{|w| = 1}$

23. For the given epicyclic gear train if the Gear A is fixed and Arm C makes 20 revolutions, the number of revolutions made by Gear B will be



A. 75 revolution

B. 25 revolutions

C. 50 revolutions

D. 100 revolutions

Ans. D

Sol.

Condition	*Arm C*	*A (100)*	*B (25)*
Arm fixed and +x rotation to A	0	+x	-x×100/25
Arm rotated by y	y	(y + x)	(y - 4x)

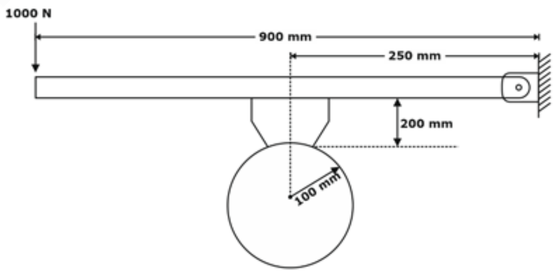
Gear A is fixed, y + x=0

y = 20 revolutions (given)

x = -20 rev

N_B = y-4x = 20 - (4*-20) = 20+80 = 100 rev

24. A brake drum (as shown in figure) is rotating in anticlockwise direction. Coefficient of friction between drum and shoe is 0.25. The braking torque for the shoe will be

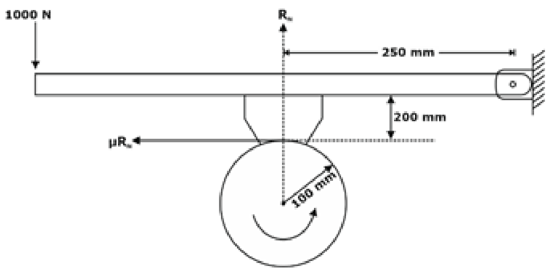


A. 50 N-m B. 75 N-m

C. 100 N-m D. 150 N-m

Ans. B

Sol.



Taking moment about hinge,

$\sum M_O = 0$

$1000\times900 = R_N\times250 + F_f\times200$

$\{F_f = \mu R_N = 0.25 R_N\}$

$1000\times900=300R_N$

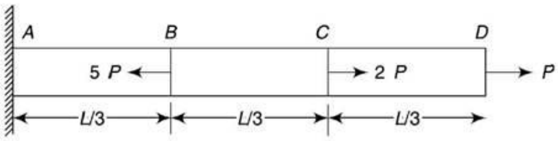
$R_N = 3000$ N

$T_R = F_f \times$radius of brake drum

$T_R = \mu R_N\times R$

$T_R = 3000*0.25*100 = 75000$ N-mm = 75 N-m

25. The figure shows a steel bar subjected to various loads. The bar has area A and modulus of elasticity E. The strain energy stored in the bar is :



A. $\frac{7}{3}\frac{P^2L}{AE}$

B. $\frac{5}{3}\frac{P^2L}{AE}$

C. $\frac{4}{3}\frac{P^2L}{AE}$

D. $\frac{P^2L}{AE}$

Ans. A

Sol. As shown in the figure:

The force in segment CD is $F_{CD} = P$ (tensile)

The force in segment BC is $F_{BC} = 3P$ (tensile)

The force in segment AB is $F_{AB} = -2P$(compressive)

The strain energy of the bar will be :

$$\sum\frac{P^2L}{2AE} = \frac{L}{3}x\frac{1}{2AE}[P^2+(3P)^2+(-2P)^2] = \frac{7}{3}x\frac{P^2L}{AE}$$

26. A laminar fluid flow having Prandtl number 0.85 flows over a flat plate having plate temperature 650 K. If δ is hydraulic boundary layer thickness and δ_T is the thermal boundary layer thickness, then which relation is correct?

A. $\delta = 0$ and $\delta_T \neq 0$

B. $\delta < \delta_T$

C. $\delta > \delta_T$

D. $\delta = \delta_T$

Ans. B

Sol. Solution:

Prandtl number,

Pr = 0.85

As, $Pr = \frac{\delta}{\delta_T} = 0.85$

So, $\delta = 0.85\,\delta_T$

$\therefore\ \delta < \delta_T$

27. Air in a room is at 35 °*C* and 60% relative humidity (RH) The pressure in the room is 0.1 MPa The saturation pressure of water at 35 °*C* is 5.63 kPa. The humidity ratio of the air (in grain/kg of dry air) is___

A. 21.74
B. 22.20
C. 25.17
D. 20.37

Ans. A

Sol. **Solution:**

DBT of air = 35 °*C*

Air pressure = P_t = 0.1MPa = 100 kPa

Saturation pressure of water = P_{vs} = 5.63 kPa

Relative Humidity of air =

$$\phi = 0.60 = \frac{P_V}{P_{VS}} = \frac{P_V}{5.63}$$

$$P_V = 3.378kPa$$

Humidity ratio of the air =

$$\omega = 0.622\left(\frac{P_V}{P_t - P_V}\right) = 0.622\left(\frac{3.378}{100-3,378}\right) = .02174$$

kg/kgda = 21.74 gm/kgda

28. The difference between the mean (μ) and variance (σ^2) of binomial distribution with n observations is

A. $\frac{\sigma^2}{n}$
B. $\frac{\mu^2}{n}$
C. $\frac{\sigma}{n}$
D. None of these

Ans. B

Sol. mean (μ) = np

variance (σ^2) = npq

mean - variance = np - npq = np (1-q) = np . p (because, 1-q = p) = $np^2 = \mu^2/n$

29. If the arrival takes place every 10 min with a service time of 4 min per unit, then the mean arrival rate, mean

service rate, and the probability that one would have to wait will be, respectively,

A. 10, 4, 0.25

B. 0.1, 0.25, 0.4

C. 10, 0.4, 0.25

D. 0.1, 0.25, 0.1

Ans. B

Sol. Given that arrival rate

λ = 1/ 10

= 0.1 units per minute

and service rate

μ = 1/ 4

= 0.25 units per minute

Therefore, the probability that one would have to wait is, ρ = λ /μ = 0.4

30. In a cam-follower mechanism, the follower needs to rise through 30 mm during 60° of cam rotation, the first 30° with a constant acceleration and then with a deceleration of the same magnitude. The initial and the final speeds of the follower are zero. The cam rotates at a uniform speed of 300 rpm. The maximum speed of the follower is

A. 2.60 m/s B. 1.80 m/s

C. 2.68 m/s D. 2.40 m/s

Ans. B

Sol. Angular velocity

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 300}{60} = 10\pi$$

Time taken to move 30

$$° = \frac{\frac{\pi}{180}\times 30}{\omega} = \frac{\pi/6}{10\pi} = \frac{1}{60} sec$$

During this time, follower moves by distance 30/2 = 15 mm with initial velocity, u =0

$$\text{Now;} \quad \frac{S}{2} = Ut + \frac{1}{2}at^2$$

$$.015 = 0 + \frac{1}{2} * a * \frac{1}{60} * \frac{1}{60}$$

$$a = 108$$

$$V = u + at$$

$$V = 0 + 108 * \frac{1}{60} = 1.8 m/\sec$$

31. Match List I and List II and select the correct answer using the code given below the lists:

	List-I (Casting process)		List-II (Limitation)
P.	Shell Mold Casting	1.	Axis of rotation is only in horizontal
Q.	Investment Casting	2.	Only for low melting point materials
R.	Die casting	3.	Upto 5 kg castings
S.	Centrifugal casting	4.	Phenolic Regin as mold material
		5.	Only wood pattern

A. P-1, Q-2, R-3, S-4

B. P-2, Q-1, R-4, S-3

C. P-3, Q-4, R-1, S-2

D. P-4, Q-3, R-2, S-1

Ans. D

Sol. Shell Mold Casting: Phenolic Regin is used as mold material.

Investment Casting: It is suitable upto 5 kg castings.

Die casting: It is used only for low melting point materials.

Centrifugal casting: In this casting, axis of rotation is only in horizontal.

32. The generalized heat conduction equation which gives the temperature distribution is given by

$$K\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right] + \dot{q} = \rho C_p\left(\frac{\partial T}{\partial \tau}\right)$$

If there is no heat generation inside the body, then this equation is known as

A. Poisson equation

B. Diffusion equation

C. Laplace equation

D. None of the above

Ans. B

Sol. The Fourier equation for conduction is,

$$\left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right] + \frac{\dot{q}}{K} = \frac{1}{\alpha}\left(\frac{\partial T}{\partial \tau}\right)$$

Where α is thermal diffusivity

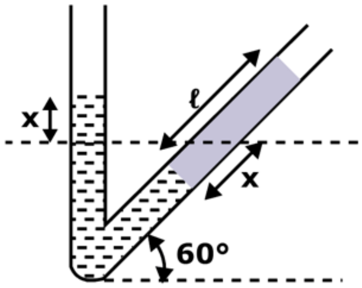
When there is no heat generation inside the body

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = \frac{1}{\alpha}\left(\frac{\partial T}{\partial \tau}\right)$$

This equation is known as diffusion equation.

33. A manometer having one limb vertical and other inclined at 60^0 to the horizontal is filled with a fluid of specific gravity 1.5 The area of tube 1 cm^2. If 20 cm^3 of additional water is filled in inclined tube, find the rise of meniscus (in cm) in vertical tube.

Sol.



$\ell = \frac{V}{A} = \frac{20}{1} = 20 \text{ cm}$

$1.5 (x + x \sin 60°) = 20 \sin 60° \times 1$

$\boxed{x = 6.18 \text{ cm}}$

34. A planer performs 30 double strokes per minute and each stroke is 120 cm long and the cutting to return time ratio is 4 : 1, if the forward stroke speed of a planer is 45 m/min and the width of the work piece is 30 cm. What should be the time taken for one cut if the feed of the table is 0.1 mm/double stroke ?

A. 10 B. 100
C. 1000 D. 10000

Ans. B

Sol. $\text{Time/Cut} = \frac{B}{f} \times \frac{L}{V} \times (1 + M)$

$= \frac{300}{0.1} \times \frac{1200}{45} \times \left(1 + \frac{1}{4}\right) = 100$

35. For the density function shown

$$f_x(x) = \begin{cases} xe^{-x^2/2}, x \geq 0 \\ 0 \quad\quad x < 0 \end{cases}$$

P (1 < x < 2) is ....

Sol. $p(1 < x < 2) = \int_1^2 xe^{-x^2/2}.dx$

Let $\frac{x^2}{2} = t$

$\therefore$ xdx = dt

$P(1 < x < 2) = \int_{1/2}^{2} e^{-t} dt$

$= [-e^{-t}]_{\frac{1}{2}}^{2}$

$\therefore$ P (1 < x < 2) = 0.47

36. A horizontally laid pipe used for transporting water has a sudden contraction in hydraulic diameter from 0.4m to 0.3m. The pressure across the contraction reads 0.4MPa and 0.25Mpa respectively. Assuming the mass flow rate as 500kg/s. Determine the magnitude of force exerted(in KN) on the contraction due to the flow, assuming friction is absent.

Sol.

$A_1 = \frac{\pi}{4}(0.4)^2 = 0.1256 \text{ m}^2$

$|A_2 = \frac{\pi}{4}(0.3)^2 = 0.0706 \text{ m}^2$

$V_1 = \frac{\theta}{A_1}, V_2 = \frac{\theta}{A_2}$

$\theta = \text{discharge} = \frac{\text{mass flow}}{density} = \frac{500}{1000} m^3/s$

$= 0.5 \text{ m}^3/\text{s}.$

$V_1 = 3.979 \text{ m/s}, V_2 = 7.082 \text{ m/s}$

$-F_X = P_1A_1 - P_2A_2 \cos\theta - PQ (r_2 \cos\theta - V_1)$

$-F_X + 400 \times 1000 \times 0.1256 - 250 \times 1000 \times 0.0706 \times 1$

$= 1000 \times 0.5 (7.082 - 3.979)$

$F_X = +31.0385 \text{ KN}.$

37. let $\bar{r} = yz\,\bar{i} + zx\,\bar{j} + xy\,\bar{k}$, then the value of div $\bar{r}$ and curl $\bar{r}$ are respectively

A. (0 , 3) B. (0, 0)
C. (3, 0) D. (0, $\bar{r}$)

Ans. B

Sol.

$\text{div } \bar{r} = \nabla.\bar{r} = \frac{\delta}{\delta x}(yz) + \frac{\delta}{\delta x}(zx) + \frac{\delta}{\delta x}(xy) = 0$

Curl

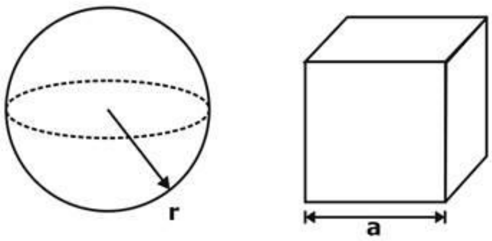
$\bar{r} = \nabla \times \bar{r} = \bar{i}\left\{\frac{\delta}{\delta y}(xy) - \frac{\delta}{\delta z}(zx)\right\} +$

$\bar{j}\left\{\frac{\delta}{\delta z}(yz) - \frac{\delta}{\delta x}(xy)\right\} + \bar{k}\left\{\frac{\delta}{\delta z}(zx) - \frac{\delta}{\delta z}(yz)\right\}$

$= \bar{i}\{x - x\} + \bar{j}\{y - y\} + \bar{k}\{z - z\} = 0$

38. Two castings of the same material have same surface area. One casting is in the form of a sphere and other is a cube. The ratio of solidification time for sphere to that for the cube is ______.

Sol.



$A_1 = A_2$

$4\pi r^2 = 6a^2$

$$\frac{r}{a} = \left(\frac{3}{2\pi}\right)^{1/2}$$

$$\frac{t_1}{t_2} = \left(\frac{V_1}{V_2}\right)^2 = \left(\frac{\frac{4}{3}\pi r^3}{a^3}\right)^2$$

$$= \left(\frac{4}{3}\pi\right)^2\left(\frac{3}{2\pi}\right)^3 = \frac{6}{\pi} = 1.909$$

39. List 1 shows the codes of CNC machine and list 2 shows the functions associated with them. Match the two accordingly

List 1

P) G 33

Q) G 35

R) G91

S) G 80-89

List 2

1) Incremental input dimensions

2) Canned cycles

3) Constant lead thread cutting

4) Linearly decreasing lead thread cutting

A. P3 Q4 R1 S2

B. P3 Q1 R4 S2

C. P4 Q2 R1 S3

D. P4 Q2 R3 S1

Ans. A

Sol. The codes correspond to the functions in the list

P) G 33

3) Constant lead thread cutting

Q) G 35

4) Linearly decreasing lead thread cutting

R) G 91

1) Incremental input dimensions

S) G 80-89

2) Canned cycles

40. The torque developed by an engine is given by the following equation: $T=14000+2000\sin\theta-1500\cos\theta$, where T is the torque in N-m and θ is the crank angle measured from inner dead center. The resisting torque of the machine is constant throughout the work cycle. The coefficient of fluctuations of speed of engine running at at a speed of 150rpm is 0.02.if A solid circular steel disk is used as a flywheel then moment of inertia fo the flywheel will be __________ kg-m^2.

Sol. Solution: Given; N=150rpm, C_s=0.02, t=50mm , ρ=7800 kg/m^3

E = $\int_A^B (T - T_m)\,d\theta$; where A and B are points of maximum and minimum angular velocity points on the graph as shown in graph below.

For this first we need to find mean torque T_m

In the torque equation the fluctuating terms (sinθ) and (cosθ) have a zero mean. Therefore the mean torque is given by,

T_m = 14000N-m

To find points A and B,

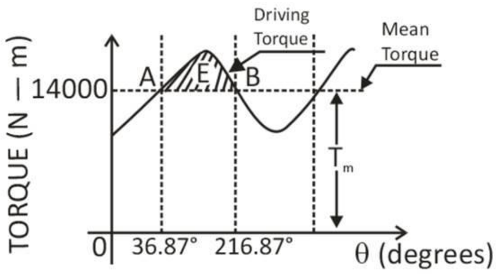
$T=T_m$

$$\therefore 2000\sin\theta - 1500\cos\theta = 0$$

$$\therefore \tan\theta = \frac{1500}{2000}$$

Thus

$$\theta = 36.87^\circ \text{ or } \theta = 180 + 36.87 = 216.87^\circ$$



$\therefore E = \int_{36.87}^{216.87} (2000\sin\theta - 1500\cos\theta)\, d\theta$

$= [-2000\cos\theta - 1500\sin\theta]_{36.87}^{216.87}$

$\therefore E = 5000J$

Now to calculate the outer radius of disc, we know

E = $I\omega^2 C_s$

Here $\omega = \frac{2\pi N}{60}$

$= \frac{2\pi \times 150}{60}$

= 15.708 rad/s

$\therefore I = \frac{E}{\omega^2 C_s}$

= 1013.20 kg-m^2

41. A project consist of three activities and they are arranged consecutively in order A,B,C and the time period of successive activities is 2 days ,3 days and 5 days respectively. The standard deviation of successive activities is 4,3 and 12 respectively. The probability to complete the project in 23 days is ______. Assume project duration to follow normal distribution.

Sol. The expected project completion time is the 2+3+5=10days

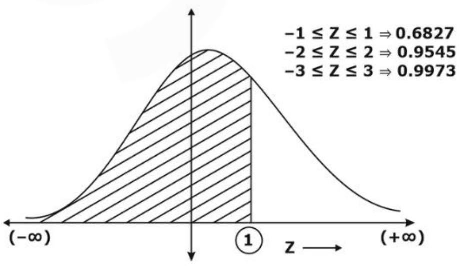
The standard deviation of the project is $\sqrt{4^2 + 3^2 + 12^2} = 13\ days$

As per the normal distribution,

$Z = \frac{x - \mu}{\sigma} = \frac{23 - 10}{13} = 1$

So as per the normal distribution the probability of completion of project is,

$0.5 + \frac{.6827}{2} = 0.84135$



42. A close cycle gas turbine plant operating on Brayton cycle between 300 K and 1100 K. Some more data pertaining to the cycle are given below:

Pressure ratio of the cycle-= 5

Compressor efficiency-= 0.8

Calorific value of fuel-= 41800 kJ/kg

Combustion loss-= 10% of heating value

C_P = 1.005 kJ/kgK

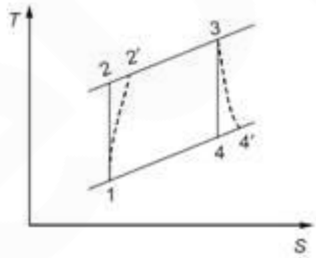
γ = 1.4

Air-fuel ratio for the plant is

Sol.

$T_2 = T_1 \times (r_p)^{\frac{1-\gamma}{\gamma}}$

$= 300 \times (5)^{\frac{0.4}{1.4}} = 475.15\ K$



$\eta_c = \frac{T_2 - T_1}{T'_2 - T_1}$

$\Rightarrow 0.8 = \frac{475.15 - 300}{T'_2 - 300}$

$\Rightarrow T'_2 = 519\ K$

Heat supplied, $Q_s = C_p(T_3 - T'_2)$

$= 1.005(1100 - 519)$

= 584 kJ/kg of air

As 10% of heating value is lost i.e. efficiency of heat is 90%. So, each kg of fuel contributes

$0.9 \times 41800 = 37620$ kJ

$\therefore$ Air fuel ratio $= \frac{37620}{584} = 64.4$

43. In a constant pressure process, 1kg of air at 300 K is mixed with 1 kg air at 400 K. If the pressure is 100 kPa and Q = 0, the entropy generation in the process will be

A. 0.0414 kJ/K B. 0.414 kJ/K

C. 0.0207 kJ/K D. 0.207 kJ/K

Ans. C

Sol. We consider all the air as control volume. Then the energy equation and entropy equation for this control volume gives,

$\upsilon_2 - \upsilon_1 = 0 - W$ ...(i)

$s_2 - s_1 = 0 + {}_1 s_{2gen}$ ...(ii)

For the constant pressure process, the work is

$W = p(\upsilon_2 - \upsilon_1)$

Substituting into equation (i), gives

$\upsilon_2 - \upsilon_1 + W = \upsilon_2 - \upsilon_1 + p(\upsilon_2 - \upsilon_1) = 0$

Or, $H_2 - H_1 = 0$

Due to the low T let us use constant specific heat. Thus,

$H_2 - H_1 = m_A (h_2 - h_1)_A + m_B (h_2 - h_1)_B$

$= 0$

$= m_A c_p (T_2 - T_{A1}) + m_B c_p (T_2 - T_{B1}) = 0$

or,

$$T_2 = \frac{m_A T_{A1} + m_B T_{B1}}{m_A + m_B} = \frac{T_{A1} + T_{B1}}{2} = \frac{300 + 400}{2}$$

$= 350K$

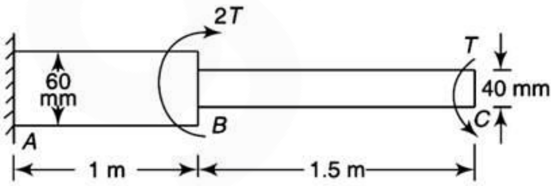
Now, the entropy change from equation (ii) with no change in pressure is

$$s_{12gen} = s_2 - s_1 = m_a c_p \ln\frac{T_2}{T_{A1}} + m_B c_p \ln\frac{T_2}{T_{B1}}$$

$$= (1 \times 1.005) \times \ln\left(\frac{350}{300}\right) + (1 \times 1.005) \times \ln\left(\frac{350}{400}\right)$$

$= 0.0207$ kJ/K

44. A stepped steel shaft is subjected to a torque T at the free end and a torque 2T in the opposite direction at the junction as shown below:



The maximum permissible shear stress in the shaft is limited to 80 MPa and the modulus of rigidity of the shaft is 80 GPa. The magnitude of the total angle of twist of the shaft at the free end(in degrees) is __________

Sol. The torque in section BC is : T (CCW)

Torque in section AB is : 2T-T= T (CW)

Thus, torque in both sections is same but in opposite direction.

To find the permissible value of T:

Consider portion BC:

$$\tau = \frac{16T}{\pi D_{BC}^3}$$

$$80 = \frac{16T}{\pi 40^3}$$

$giving\ T = 1005.3\ N - m$

For portion AB :

$$80 = \frac{16T}{\pi 60^3}$$

$giving\ T = 3392.92\ N - m$

As shear stress

$\tau\ \alpha\ T, the\ lower\ value\ of\ T\ governs.$

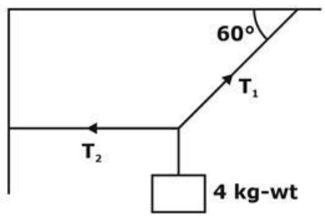
Thus, $T = 1005.3\ N - m$

The total angle of twist will be :

$$\theta = \frac{T}{G} x \left[\frac{L_{BC}}{J_{BC}} - \frac{L_{AB}}{J_{AB}}\right]$$

$$\theta = \frac{32x1005300}{80000x\pi}\left[\frac{1500}{40^4} - \frac{1000}{60^4}\right] = 0.065\ rad = 0.065x\frac{180}{\pi} = 3.73°$$

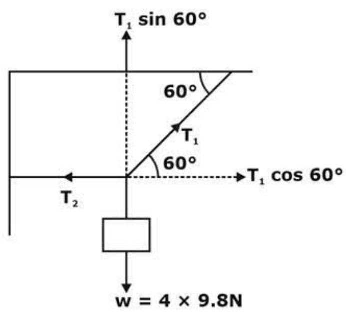
45. Determine the tension T_2 in the strings as shown in figure.



A. 19.6N
B. 29.4N
C. 45.26N
D. 22.63N

Ans. D

Sol.



Resolving the tension T_1 along horizontal and vertical directions. As the body is in equilibrium,

$T_1 \sin 60° = 4 \times 9.8N$ …(i)

$T_1 \cos 60° = T_2$ ….(ii)

From Eq. (i)

$$T_1 = \frac{4 \times 9.8}{\sin 60°} = \frac{4 \times 9.8 \times 2}{\sqrt{3}} = 45.26 \text{ N}$$

Putting this value in Eq. (ii)

$T_2 = T_1$ cost $60° = 45.26 \times 0.5 = 22.63$ N

46. A pump having efficiency 85% is running at a speed of 4800 rpm and delivers 2.5 m^3/s of water under a head of 20 m. The power input to a pump (in kW) at a shaft speed of 1600 rpm under same head will be

A. 18.14 B. 192.35
C. 577.06 D. 21.37

Ans. D

Sol. Given, $\eta_o = 0.85$, $Q = 2.5\ m^3/s$, $H = 20$ m, $N_1 = 4800$ rpm, $N_2 = 1600$ rpm

Power at 4800 rpm,

$$P_1 = \frac{\rho Q g H}{\eta_o} = \frac{10^3 \times 2.5 \times 9.81 \times 20}{0.85} =$$

577.06 kW

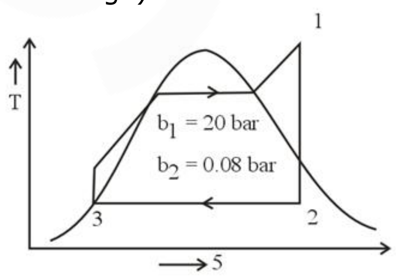
for a given pump

As, $P \propto N^3$

$$\frac{P_2}{P_1} = \frac{{N_2}^3}{{N_1}^3} = \frac{1600^3}{4800^3} = 0.037$$

Power at 1600 rpm, $P_2 = 21.37$ kW

47. The steam is expanded isentropically in steam turbine from 20 bars, 350°C to 0.08 bars and then it condensed to saturated liquid water in condenser. The pump feeds back the water into boiler. Neglect losses in the processes, the cycle efficiency (in percentage) is



Given data: At p = 0.08 bar, h_{fg} = 2403.1 kJ/kg, s_{fg} = 7.6361 kJ/kg K, $v_f = 0.001008\ m^3/kg$

h_1 =3159.3 kJ/kg, s_1 = 6.9917 kJ/kg K, h_3 = 173.88 kJ/kg, s_3 = 0.5926 kJ/kgK,

Sol. $\eta_{cycle} = \frac{W_{net}}{Q_1}$

$W_{net} = W_T - W_P$

$W_T = h_1 - h_2$

As, $s_1 = s_2 = s_3 + x\, s_{fg} = 0.5926 + 7.6361\, x$

$x = 0.838$

$h_2 = h_3 + x\, h_{fg} = 173.88 + 0.838 \times 2403.1 = 2187.68$ kJ/kg

$W_T = h_1 - h_2 = 3159.3 - 2187.68 = 971.62$ kJ/kg

$W_P = v_f\,(p_1 - p_2) = 0.001008 \times (20 - 0.08) \times 10^2 = 2$ kJ/kg

$h_4 - h_3 = 2$

$h_4 = 175.88$ kJ/kg

$W_{net} = 971.62 - 2 = 969.62$ kJ/kg

Heat added, $Q_1 = h_1 - h_4 = 2983.42$ kJ/kg

$$\eta_{cycle} = \frac{969.62}{2983.42} = 0.325 = \mathbf{32.5\ \%}$$

48. Expression for temperature distribution in steady state one dimensional heat conduction for hollow sphere having inside and outside radius is a and b respectively and inside temperature is T_1 and outside temperature is T_2 is given by

A. $T(r) = \frac{a}{r} \cdot \frac{b-r}{b-a} \cdot T_1 + \frac{b}{r} \cdot \frac{r-a}{b-a} \cdot T_2$

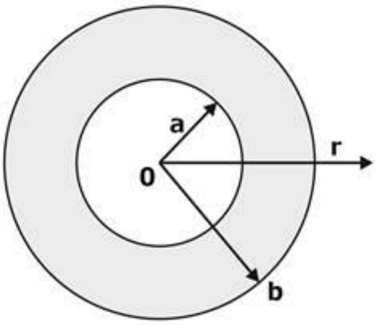
B. $T(r) = \frac{a}{r} \cdot \frac{b-r}{b-a} \cdot T_1 - \frac{b}{r} \cdot \frac{r-a}{b-a} \cdot T_2$

C. $T(r) = \frac{a}{r} \cdot \frac{b+r}{b-a} \cdot T_1 + \frac{b}{r} \cdot \frac{r+a}{b-a} \cdot T_2$

D. $T(r) = \frac{a}{r} \cdot \frac{b+r}{b-a} \cdot T_1 - \frac{b}{r} \cdot \frac{r+a}{b-a} \cdot T_2$

Ans. A

Sol.



The mathematical formulation for spherical co-ordinate system is given by,

$\frac{d}{dr}\left(r^2\frac{dT(r)}{dr}\right) = 0$ for a < r < b

So, $T(r) = \frac{-C_1}{r} + C_2 \cdot\cdot\cdot\cdot\cdot (1)$

Applying boundary condition:

At r = a, $T = T_1$

At r = b, $T = T_2$

So, $C_1 = -\frac{ab}{b-a}(T_1 - T_2)$

And $C_2 = \frac{bT_2 - aT_1}{b-a}$

Putting value of C_1 and C_2 in equation 1

$T(r) = \frac{a}{r}\cdot\frac{b-r}{b-a}\cdot T_1 + \frac{b}{r}\cdot\frac{r-a}{b-a}\cdot T_2$

49. A steel plate 50 mm thick is to be rolled to 42 mm in a four high mill having roll diameter 340 mm. The yield stress is 200 MPa. The coefficient of friction, if the given reduction is the maximum reduction possible, is

A. 0.158 B. 0.217

C. 0.312 D. 0.425

Ans. B

Sol. Rolling (four high mill)

H_0 = 50 mm

H_1 = 42 mm

$\Delta H = H_0 - H_1 = 50 - 42 = 8$ nm

D_R = 340 mm,

R = 170 mm,

σ_y = 200 MPa

We know,

Maximum reduction $(\Delta H_{max})_{pass} = \mu^2 \times R$

8 mm= $\mu^2 \times 170$

$\mu = 0.2169$

50. The modulus of the complex number $z = \frac{-3+4i}{1+i}$ is __________

Sol. The modulus of the complex number $z = \frac{a+ib}{c+id}$ is

$$|z| = \frac{|a+ib|}{|c+id|} = \sqrt{\frac{a^2+b^2}{c^2+d^2}}$$

$$|z| = \sqrt{\frac{9+16}{1+1}} = \sqrt{12.5} = 3.535$$

51. Let $f_1(x) = e^x$ and $f_2(x) = e^{-x}$ be the two defined in [a, b], then by Cauchy's MVT

A. $c = \frac{a+b}{2}$ B. $c = \sqrt{ab}$

C. $c = \frac{a+b}{2ab}$ D. None

Ans. A

Sol. $f_1 = e^x$ $f_2 = e^{-x}$

Both are continuous in [a, b]

Both are differentiable in (a, b)

$f'_2 \neq 0$ for all x in (A, b)

$$\frac{f'_1(c)}{f'_2(c)} = \frac{f_1(b) - f_1(a)}{f_2(b) - f_2(a)}$$

$$\frac{e^c}{-e^{-c}} = \frac{e^b - e^a}{e^{-b} - e^{-a}}$$

$-e^{2c} = -e^a.e^b$

$2c = a + b \Rightarrow c = \frac{a+b}{2}$

52. A compression ignition engine has a stroke and cylinder diameter of 250 mm and 150 mm respectively. The clearance volume is 0.0004 m^3 m^3 and the fuel injection takes place at constant pressure for only 5% of the stroke. The thermal efficiency of the engine in % is _______

Sol. The swept volume is :

$V_s = \frac{\pi}{4}D^2L = \frac{\pi}{4}x0.15^2x0.25 = 0.004418\ m^3$

$Clearance\ volume\ V_c = V_2 = 0.0004\ m^3$

$Given\ that: V_3 - V_2 = 0.05xV_S$

$Thus, V_3 = 0.0004 + 0.05x0.004418 = 0.000621$

$Cut - off\ ratio\ \rho = \frac{V_3}{V_2} = 1.55$

$r = \frac{V_1}{V_2} = \frac{(V_s+V_2)}{V_2} = 12.04$

Compression ratio

$r = \frac{V_1}{V_2} = \frac{(V_s+V_2)}{V_2} = 12.04$

Thus, the thermal efficiency is given by :

$\eta = 1 - \frac{1}{r^{\gamma-1}}x\frac{1}{\gamma}\left[\frac{\rho^\gamma - 1}{\rho - 1}\right]$

Putting the values we

get $\eta = 0.593 = 59.3\%$

$\eta = 0.593 = 59.3\%$

53. The actual sale and forecast value for a machine in given in following table given below.

Year	2011	2012	2013	2014	2015	2016
Sale	180	280	250	190	240	-
Farecost	190	270	240	200	250	-

With Exponential smoothing constant of 0.5, forecast for the year 2016 and mean absolute deviation between years 2011 to 2015 is respectively ?

A. 200, 10 B. 245, 10

C. 245, —2 D. 240, —10

Ans. B

Sol. $F_{2016} = F_{2015} + \alpha\ [D_{2015} - F_{2015}]$

$= 250 + 0.5\ [240 - 250]$

$F_{2016} = 245$

$MAD = \frac{|180-190|+|280-270|+|250-240|+|190-200|+|240-250|}{5}$

$= 10$

54. A small disc of radius 2 cm is cut from a disc of radius 6 cm. If the distance between their centres is 3.2 cm, what is the shift in the centre of mass of the disc ?

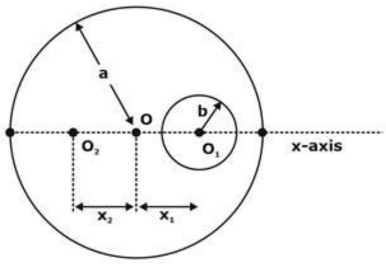
A. -0.4cm B. 0.4cm

C. 0.8cm D. -0.8cm

Ans. A

Sol. Let radius of complete disc is a and that of small disc to b.

Also, let centre of mass now shifts to O_2 at a distance x_2 from original centre.



The position of new centre of mass is given by

$x_{CM} = \frac{-\sigma\pi b^2 x_1}{\sigma\pi a^2 - \sigma\pi b^2},$

where, σ = mass per unit area

Here, a = 6 cm, b = 2 cm, x_1 = 3.2 cm

Hence, $x_{CM} = \frac{-\sigma\times\pi(2)^2\times 3.2}{\sigma\times\pi\times(6)^2 - \sigma\times\pi\times(2)^2}$

$= -\frac{12.8\pi}{32\pi} = -0.4\ cm$

Negative sign indicates the shift from the centre.

55. The value of $\int_c \bar{F}.d\bar{r},$ where $\bar{F} = x^2y^2\bar{i} + y\bar{j}$ and C is the curve $y^2 = 4x$ in the XY-plane from (0, 0) to (4, 4), is _____.

Sol. $\int_c \bar{F}.d\bar{r} = \int_c x^2y^2dx + ydy$

$Given: \quad y^2 = 4x$

$\Rightarrow \quad 2ydy = 4dx$

$\Rightarrow \quad ydy = 2dx$

$\Rightarrow \quad \int_c \bar{F}.d\bar{r} = \int_0^4 x^2 4xdx + 2dx$

$= \left[4\frac{x^4}{4} + 2x\right]_0^4 = 264$

56. A solid rod of 2cm diameter is maintained at a uniform temperature of 350K is covered with insulation having k = 0.2 W/mK to maximize heat loss to the ambient air at temperature 298 K with h_a = 15 W/m^2k. The ratio of heat loss from the rod with insulation to that without insulation Is_______

Sol. For maximize heat loss outer radius after the insulation will be equal to the critical radius

So, $r_C = \frac{K_{ins}}{h_0} = \frac{0.2}{15}$

r_C = 0.0133 m = 1.33 cm

Heat loss from the tube with insulation = $\frac{\Delta T}{\frac{ln\frac{r_c}{r_1}}{2\pi kL} + \frac{1}{h\pi D_0 L}}$ ………….. (1)

Heat loss from the tube without the insulation = hAΔT = h $\pi DL\Delta T$ …………… (2)

Ratio of equation 1 and 2 is

$$\frac{q_{with\ insulation}}{q_{without\ insulation}} = \frac{\frac{\Delta T}{\frac{ln\frac{r_c}{r_1}}{2\pi kL} + \frac{1}{h\pi D_0 L}}}{h\pi DL\Delta T}$$

$$= \frac{\frac{52}{\left(\frac{\ln\left(\frac{1.33}{1}\right)}{2\times\pi\times0.2} + \frac{1}{15\times\pi\times2\times1.33\times10^{-2}}\right)}}{15\times2\pi\times1\times10^{-2}\times52}$$

$$\frac{q_{with\ insulation}}{q_{without\ insulation}} = 1.035$$

57. Two plates are parallel placed over one another and welded . Both plates are of equal area. and one have(upper one) E=200GPa and another(lower one) E=100GPa. The temperature of both is raised by the 50C and the upper and lower plate have coefficient of linear thermal expansivity is 10^{-4}/C and 2×10^{-4} /C respectively . What will be stress in upper plate.

A. 333.33MPa B. 366.66MPa

C. 400MPa D. 200MPa

Ans. A

Sol. As both plates have the same cross section area thus the stress has to be the same,

The plate with higher value of coefficient of expansion will be in compression and the one with lower value will be in tension. Therefore, applying the condition of change in length.

We have,

$$\sigma\left(\frac{1}{E_1} + \frac{1}{E_2}\right) = (\alpha_2 - \alpha_1)\Delta T$$

$\sigma = 333.33MPa$

58. In a n orthogonal turning operation, following were the observations:

Cutting force = 1500 N

Thrust force = 750 N

Tool rake angle = 0 degrees

Cutting speed = 2 m/s

Using the Merchant's analysis,

The velocity of the chip along the tool rake face will be _____ m/s (upto two decimal places)

Sol. Given

Cutting force, F_c = 1500 N

Thrust force, F_t = 750 N

Rake angle, α = 0

Cutting speed, V = 2 m/s

Chip speed, V_c = ?

$\Rightarrow \tan(\beta - \alpha) = \frac{F_t}{F_c} = \frac{750}{1500}$

⇒ tan β = 0.5

⇒ β = 26.56°

Applying Merchant's analysis,

2φ + β – α = 90°

⇒ 2φ + 26.56 – 0 = 90°

φ = 31.71°

Now, chip velocity, $V_c = \frac{V\sin\phi}{\cos(\phi - \alpha)}$

= V tan φ

V_c = 1.23 m/s

59. A shaft is subjected to fluctuating axial load from 50 kN to 150 kN. Ultimate, strength, yield strength & endurance strength are 400 MPa, 300 MPa and 200 MPa respectively. What will be the cross-sectional area of the shaft, if factor of safety is 2. (Use Goodman criteria)

A. 500 mm^2 B. 750 mm^2

C. 1000 mm^2 D. 1500 mm^2

Ans. C

Sol. σ_{max} = 150/A kN/m^2 , σ_{min} = 50/A kN/m^2

$$\sigma_m = \frac{150+50}{2A} = \frac{100}{A}$$

$\sigma_v = \frac{150-50}{2A} = \frac{50}{A}$

According to Goodman criteria,

$\frac{\sigma_m}{\sigma_{ut}} + \frac{\sigma_v}{\sigma_e} = \frac{1}{N}$

$\left(\frac{100}{A.400} + \frac{50}{A.200}\right)10^3 = \frac{1}{2}$

A = 1000 mm^2

60. Find the ratio of skin friction drag on the front half and the rear half portions of a plate kept in a uniform stream of zero incidence assume the boundary layer to be laminar over the entire plate.

Sol. Drag force on whole length of plate,

$F = \frac{1}{2} C_d \rho A v^2$

$F = \frac{1.328}{\sqrt{Re_L}} \times \frac{\rho V^2}{2} \times (b \times L)$

$F \propto \frac{L}{\sqrt{L}}$

$F \propto \sqrt{L}$

F=k$\sqrt{L}$ ....(1)

Drag on first half of plate,

$F_1 = k\sqrt{L/2}$ = F/$\sqrt{2}$ = 0.707F (F is taken from 1st equation)

Drag on rear half of the plate= Drag on whole length of plate - Drag on first half

$F_2 = F - F_1$;

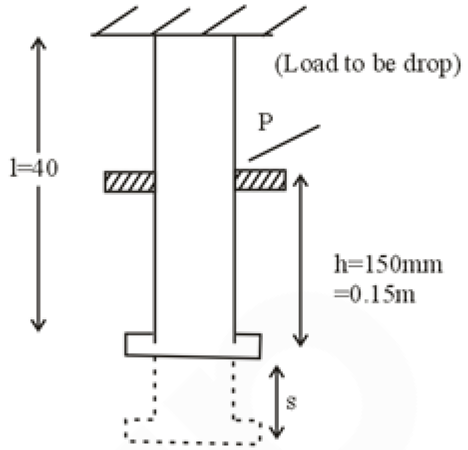
$F_2 = F - 0.707F$

$F_2 = 0.293F$

Required Ratio= $\frac{F_1}{F_2} = 2.414$

61. A 20 mm diameter, 40 m long rod provided with a rigid collar at its lower end hangs from a ceiling. This rod is stretched by a load dropping freely by gravity on the collar. The maximum load (in kN) that can be dropped from a height of 150 mm so that the elastic limit stress of 350 MPa does not exceed is (take E = 210 GPa)

Sol. Given, d= 20 mm, l = 40 m, h = 150 mm, σ = 350 MPa, E = 210 GPa



Loss of potential energy = total strain energy stored in rod

P (h+δl) = $\frac{\sigma^2}{2E}$ × V (i)

Where,

P = maximum load to be dropped

A = $\frac{\pi}{4}$ × $(0.02)^2$ = 0.000314 m^2

V = volume = A × l = $\frac{\pi}{4}$ × $(0.02)^2$ × 40 = 0.01256 m^3

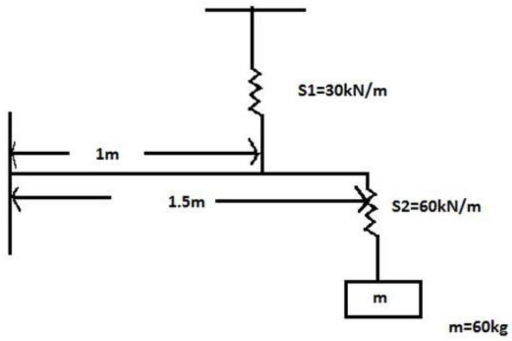
$\delta l = \frac{\sigma l}{E} = \frac{350 \times 4}{210000}$ = 0.067 m

From (i)

P (0.15 + 0.067) = $\frac{(350\times10^6)^2}{2\times210\times10^9}$ × 0.01256

P = 16881.72N = 16.881 kN

62. Calculate the natural frequency of the system?



A. 10rad/s B. 13.48rad/s

C. 15.4rad/s D. none

Ans. B

Sol. let, F_1 = force developed in spring S_1

F_2 = force developed in spring S_2

$$\delta_2 = \frac{60g}{60 \times 10^3} = 9.81mm$$

= deflection in spring S_2

$$\sum M_0 = 0$$

$$F_1 \times 1 = 60g \times 1.5$$

$$F_1 = 90g$$

$$\delta_1 = \frac{90g}{30 \times 10^3}$$

$$= 29.43mm$$

Due to deflection of δ_1 ,

corresponding deflection at (2)

$$= 1.5\delta_1 = 44.145mm$$

$$\delta_e = 44.145 + 9.81 = 53.955mm$$

$$\therefore w_n = \sqrt{\frac{g}{\delta_e}}$$

$$w_n = \sqrt{\frac{9.81}{53.955 \times 10^{-3}}}$$

$$= 13.48\, rad/sec$$

63. A power source characteristics of a DC welding power source is given by $V = I^2 - 200I - 4$ Volts. The current (amp) for maximum power is _____ .

Sol. $P = VI = (I^2 - 200I - 4)I = I^3 - 200I^2 - 4I$

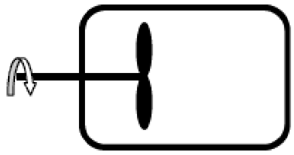
For maximum power

$$\frac{dP}{dI} = 0 \Rightarrow 3I^2 - 400I - 4 = 0$$

$$I = \frac{400 \pm \sqrt{400^2 + 4 \times 3 \times 4}}{2 \times 3} = 133.34 \text{ amp}$$

Other answer is negative.

64. In a closed rigid vessel, air is initially at a pressure of 0.3 MPa and volume of 0.1 m^3 at 300 K. A stirrer supplies 100 kJ of work to the air, while 20 kJ of heat is lost to the atmosphere across the container walls. After these processes, the temperature of air changes to



A. 321.9 K B. 702.4 K

C. 782.4 K D. 619.8 K

Ans. D

Sol. $W_{in} = -100\, kJ \;\; Q = -20\, kJ$

By first law:

$\Delta U = mC_v(T_2 - T_1) = Q - W$ = 20-(-100)= 80KJ

By equation of state $m = \frac{PV}{RT} = \frac{0.3x1000x0.1}{0.287x300} = 0.3484\, kg$

Thus,

$$80 \times 1000 = 0.3484 \times 718 \times (T - 300)$$

$$T = 619.78K$$

65. The second approximation of equation 3x = cos x + 1 between 0 and 1 with initial guess of x_0 = 0.6 by Newton Raphson method is

A. 0.607 B. 0.517

C. 0.606 D. 0.350

Ans. A

Sol. f(x) = 3x - cos x - 1

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$x_{n+1} = x_n - \frac{3x_n - \cos x_n - 1}{3 + \sin x_n}$$

$$x_0 = 0.6, x_1 = 0.6 - \frac{3(0.6) - \cos(0.6) - 1}{3 + \sin 0.6}$$

$$= 0.6071$$

$$x_2 = x_1 - \frac{3x_1 - \cos x_1 - 1}{3 + \sin x_1} = 0.6071 - \frac{3(0.6071) - \cos(0.6071) - 1}{3 + \sin(0.6)}$$

$$x_2 = 0.6071$$

****

Next Mega Mock Challenge

ISRO 2019-20 ME/EC/CS

08 Jan(12 PM) to 09 Jan(12 PM)

Register Now

GATE 2020 ME/EC/CS/EE/CE

15 Jan(12 PM) to 16 Jan(12 PM)

Stay Connected

gradeup