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ISRO 2020 Mechanical Engineering

Mega Mock Challenge
(08 Jan-09 Jan 2020)

Questions & Solutions

1. A plate of width 2 m and length 2.5 m placed in a stream of oil of specific gravity 0.8 and kinematic viscosity $10^{-5}\frac{m}{s^2}$ is moved at a speed of 1 m/s along the length. The drag coefficient is given by:

$$C_D = \frac{0.65}{\sqrt{Re}}$$

The shear stress at the trailing edge in Pa is:

A. 0.52 B. 0.85
C. 2.42 D. 3.5

Ans. A

Sol. The Reynold's number is:

$$Re = \frac{VL}{\nu} = \frac{1x2.5}{10^{-5}} = 250000$$

The drag coefficient will be:

$$C_D = \frac{0.65}{\sqrt{250000}} = \frac{0.65}{500} = 1.3x10^{-3}$$

The shear stress will be:

$$\tau = \frac{1}{2}C_D\rho U^2 = 0.5 \times 1.3x10^{-3}$$

$$\times 0.8 \times 1000 \times 1^2 = 0.52\ Pa$$

2. Consider a 4cm diameter and 6cm long cylindrical rod at 1000K. If the emissivity of the rod surface is 0.75, the total amount of radiation emitted by all surfaces of the rod in 20mm is

A. 43 kJ B. 385 kJ
C. 434 kJ D. 513 kJ

Ans. D

Sol. The total surface area of rod is,

$$A_s = 2\times\frac{\pi}{4}(D)^2 + \pi DL$$

$$= 2\times\frac{\pi}{4}(0.04)^2 + \pi\times 0.04\times 0.06 = 0.01005m^2$$

The heat flux is

$$q = \varepsilon\sigma T^4 = 0.75\times 5.67\times 10^{-8}\times(1000)^4$$

= 42525 W/m^2

Then, total amount of radiation emitted by all surfaces of the rod is,

Q = qA_st = 42525 × 0.01005 × 20 × 60

= 513 KJ

3. During a certain experimental process, a semi-circular plane (radius = 0.5m), is being susceptible to a constant gas pressure of 420 kN/m^2. Calculate the approximate moment of thrust on the semi-circular area about its straight edge?

A. 25 kN/m B. 22.5 kN/m
C. 70 kN/m D.35 kN/m

Ans. D

Sol. Force will be defined:

$$Force(F) = p \cdot A$$

$$\therefore F = 420 \times \frac{\pi \times 0.5^2}{2}$$

$$Also, Moment(M) = F \times \bar{h}$$

$$\therefore M = 420 \times \frac{\pi\times 0.5^2}{2}\times\frac{4\times 0.5}{3\times\pi} = 35kNm$$

4. A clutch has 100 mm outer and 50 mm inner diameter. Normal force applied between plates is 10 kN and friction coefficient of a liner material is 0.2. According to uniform wear theory, torque carrying capacity of the clutch will be

A. 75 N.m B. 150 N.m
C. 300 N.m D. 400 N.m

Ans. A

Sol. R_o = 100/2 = 50 mm, R_i = 50/2 = 25 mm, W= 10 kN = 10000 N

Torque in case of uniform wear theory is given by,

$$(T_f)_{UWT} = \mu.W.\frac{R_o + R_i}{2} = 0.2 * 10000 * \frac{50+25}{2*1000} = 75\ Nm$$

5. A long wire of 1 mm diameter is submerged in an oil bath of temperature T_∞ = 25°C. The wire has an electrical resistance per unit length of wire = 0.01Ω/m. If a current of I = 100 A flows through the wire and the convection coefficient is h = 500 W/m^2-K, the steady-state temperature of the wire will be

A. 66.5°C B. 106.4°C
C. 88.7°C D. 186.3°C

Ans. C

Sol. Given,

d= 1mm, h = 500 W/m^2-K

electrical resistance per unit length of wire (R/l) = 0.01Ω/m.

T_∞ = 25°C.

By applying energy balance, we have

$$\dot{E}_g - \dot{E}_{out} = \dot{E}_{system}$$

For steady state $\dot{E}_{system} = 0$

or $\dot{E}_g = \dot{E}_{out}$

Where energy generation is due to the electric resistance heating,

$E_g = I^2R$

And energy out flow is due to convection only,

$E_{out} = hA_s(T_s - T_\infty)$ $A_s = \pi dl$

thus,

$I^2R = hA_s(T_s - T_\infty) = h\pi dl(T_s - T_\infty)$

$I^2(R/l) = h\pi d(T_s - T_\infty)$

$$100^2 \times 0.01 = 500 \times \pi \times 0.001 \times (T - 25)$$

$$T = 88.66°C$$

6. Consider the flow of a fluid across a cylinder maintained at a constant temperature. If the free-stream velocity of the fluid is doubled then what will be the ratio of the rate of heat transfer between the fluid and the cylinder? Assume $Nu \propto Re^{0.5}$.

A. 1.414 B. 1.760
C. 1.482 D. 1.201

Ans. A

Sol. The rate of heat transfer between the fluid and the cylinder is given by Newton's law of cooling. Then

$$\dot{Q}_1 = hA_s(T_s - T_\infty) = \left(\frac{k}{D}Nu\right)A_s(T_s - T_\infty)$$

$$= \frac{k}{D}(\text{Re})^{0.5}A_s(T_s - T_\infty)$$

$$= \frac{k}{D}\left(\frac{VD}{v}\right)^{0.5}A_s(T_s - T_\infty)$$

$$= V^{0.5}\frac{k}{D}\left(\frac{D}{v}\right)^{0.5}A_s(T_s - T_\infty)$$

When the free-stream velocity of the fluid is doubled, the heat transfer rate becomes

$$\dot{Q}_2 = (2V)^{0.5} \times \frac{k}{D}\left(\frac{D}{v}\right)^{0.5}A(T_s - T_\infty)$$

The ratio of them yields,

$$\frac{\dot{Q}_2}{\dot{Q}_1} = \frac{(2V)^{0.5}}{V^{0.5}} = 2^{0.5} = 1.414$$

7. A mild steel specimen of tapered circular crossection has diameter of 40 mm at one end and 14 mm at another end. If length of the specimen is 100 mm, then the elongation of the specimen under a tensile load of 220 kN will be [Take, E = 200 kN/mm^2]

A. 0.25 mm B. 2.50 mm
C. 50 mm D. 0.50 mm

Ans. A

Sol. d_1 = 40 mm, d_2 = 14 mm, L = 100 mm, P = 220 × 10^3 N

∴ Elongation of tapered crossection, $\delta L = \frac{4PL}{\pi d_1 d_2 E}$

$$\therefore \delta L = \frac{4 \times 220 \times 10^3 \times 100}{\frac{22}{7} \times 40 \times 14 \times (200 \times 10^3)} = \frac{4 \times 220 \times 10^3 \times 100 \times 7}{22 \times 40 \times 14 \times 200 \times 10^3} = 0.25 \text{ mm}$$

8. A long plate having 200 mm width & 10 mm thickness have circular hole in centre of 50 mm diameter. The plate is subjected to tensile load of 5 KN along the length. Maximum stress generated in plate will be:

A. 2.5 MPa B. 5 MPa
C. 7.5 MPa D. 10 MPa

Ans. D

Sol. Nominal stress σ_n = P/(w-d)t

$= \frac{5000}{(200-50)\times 10}$ N/mm^2

σ_n = 3.33 MPa

Maximum stress, $\sigma_{max} = k_t\, \sigma_n$ = 3 × 3.33 = 10 MPa

(k_t = theoretical stress concentration factor for hole = 3)

9. The density function of repairing a machine is given by $f(x) = \frac{1}{2}e^{\frac{-x}{2}}$ where 'x' is repair time in hours. The probability that the repair time is more than 2 hours is

A. 0.368 B. 0.482
C. 0.518 D. 0.632

Ans. A

Sol. Probability $= \int_2^\infty f(x)\,dx$

$$= \int_2^\infty \left[\frac{1}{2}e^{\frac{-x}{2}}\right]dx$$

$$= \left[-e^{\frac{-x}{2}}\right]_2^\infty = e^{-1} = 0.368$$

10. The value of constant 'a' so that the vector

$\vec{V} = (4x + 2y + 3z)\hat{\imath} + (-x + 2y - z)\hat{\jmath} + (3x + 4y + az)\hat{k}$

is solenoidal:

A. 6 B. -6
C. $\sqrt{6}$ D. 1/6

Ans. B

Sol. For solenoidal:

$$div\ \vec{V} = 0$$

$$div\ \vec{V} = \nabla \cdot \vec{V} = 0$$

$$= \frac{\partial}{\partial x}(4x + 2y + 3z) + \frac{\partial}{\partial y}(-x + 2y - z) + \frac{\partial}{\partial z}(3x + 4y + az) = 0$$

$$\Rightarrow 4 + 2 + a = 0$$

$$\Rightarrow a = -6$$

So, the correct option is (b).

11. Which of the following factors aids in increasing detonation in SI engine?

1) Increase in spark advance
2) Higher speed
3) Increased air-fuel ratio on the far side of stoichiometric strength
4) Higher compression ratio.

Select the exact answer from below options:

A. 1 and 3 B. 2 and 4
C. 1, 2, & 4 D. 1 and 4

Ans. D

Sol. Detonation in the S.I. engines is augmented by increasing spark advance and
Increase in compression ratio. The increased speed and lean mixtures do not have much influence.

12. Calculate the number of instantaneous centers of rotation for an 8 - link mechanism?

A. 16 B. 28
C. 32 D. 8

Ans. B

Sol. As per the definition of Kennedy's Theorem, we have:

$$\text{No. of Instantaneus centre }(N) = \frac{n(n-1)}{2}$$

$$\therefore N = \frac{8 \times (8-1)}{2} = 28$$

13. A heat engine primover using source as clear reservoir water at 12°C & sink as the surrounding atmosphere at 2°C; enforces 1080 cycles/min. Determine the output of the primover, if amount of heat supplied per cycle is 57 J.

A. $66W$ B. $56W$
C. $46W$ D. $36W$

Ans. D

Sol. By definition:

$$\eta = 1 - \frac{T_2}{T_2} = 1 - \frac{275}{285} = 0.0351$$

$$\therefore Output = \eta.\ Q = 0.0351 \times 57 / cycle = 2\ J / cycle = 2 \times \left(\frac{1080}{60}\right) = 36W$$

14. Every diagonal element of a skew-symmetric matrix is

A. 1
B. 1 or 0
C. 0
D. Any real number

Ans. C

Sol. Let A be any skew-symmetric matrix

$$\Rightarrow a_{ij} = -a_{ji}$$

For diagonal elements of a matrix, we can put i = j

$$\Rightarrow a_{ij} = -a_{ii}$$

$$\Rightarrow 2a_{ii} = 0$$

$$\Rightarrow a_{ii} = 0$$

Therefore every element in the principal diagonal is necessarily 0.

So, the correct option is (c).

15. Moist air at 1 bar & 30°C contains 20 gm of water vapour per kg of dry air then, what will be specific humidity?

A. 4.84 kPa B. 2.115 kPa
C. 2.775 kPa D. 3.115 kPa

Ans. D

Sol. $w = 0.622 \frac{P_v}{P_t - P_v}$ $w = \frac{20}{1000}$

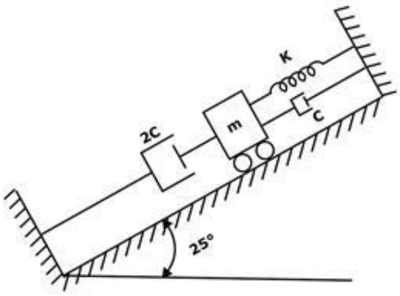
Kg/Kg of dry are

$$\frac{20}{1000} = 0.622 \times \frac{P_v}{100 - P_v}$$

P_t = 1 bar = 100 kPa

P_v = 3.115 kPa

16. Calculate the value of c(Ns/m) for the given vibration assembly where damping factor is 0.45. Stiffness of spring is 250N/m and mass of block is 10kg



A. 15 B. 20
C. 25 D. 10

Ans. A

Sol. Effective damping = 2c + c = 3c
Damping factor = 3c/2mw
w = natural frequency
w = $\sqrt{k/m} = 5$
c = $\frac{2\xi mw}{3} = 15\ Ns/m$

17. According to Raults law when an impurity is added to a pure metal then its melting point___________
A. increases
B. decreases
C. remain same
D. cannot be estimated

Ans. B

Sol. • According to Raults law, when an impurity is added to a pure metal then its melting point decreases

18. Which of the following property is an example of Extensive property:
A. Specific Volume
B. Enthalpy
C. Volume
D. Both C and B

Ans. D

Sol. Extensive properties are those which are dependent on the mass or extent of the system under consideration. Clearly Volume and Enthalpy are dependent on the mass of the system under consideration.
Some other extensive properties are Energy, Entropy.

19. With decrease in temperature, which of the following, in general will result in nature of change in viscosity:
A. For Gases → Increase, Liquids → Decrease
B. For Gases → Decrease, Liquids → Increase
C. For Gases & Liquids → Decrease
D. For Gases & Liquids → Increase

Ans. A

Sol. With decrease in temperature, the viscosity of water decreases & that of air increases.

20. Calculate the required blanking force $(in\,kN)$ if a disc of 300 mm diameter is blanked from a strip of an Al-Cu alloy of thickness 6.2 mm and the fracture material shear strength is $150\,MPa$.
A. 291 B. 891
C. 811 D. 876.5

Ans. D

Sol. Data:
$D = 300\,mm, t = 6.2\,mm, \tau = 150\,MPa$
Blanking Force
$= \pi d t \tau = \pi \times 300 \times 6.2 \times 150 = 876.5\,kN$

21. The point of contraflexure in case of beams is:
A. The point, where shear force is zero
B. The point, where shear force changes its sign
C. The point, where bending moment is zero and changes its sign
D. The point, where no load acts on the beam.

Ans. C

Sol. At point of contraflexure, bending moment on beam is zero and changes its sign.

22. A cube which is free to expand on all sides is given a temperature rise of 40℃. The length of cube is 2 m. The coefficient of expansion is 20μm/m℃. Volumetric Strain observed in cube is
A. 2.4×10^{-3} B. 24×10^{-3}
C. 19.2×10^{-3} D. 1.92×10^{-3}

Ans. A

Sol. Volumetric strain of cube=3×Linear Strain
$=3\times\alpha\times\Delta T$
$=3\times20\times10^{-6}\times40$
$=2.4\times10^{-3}$

23. In a convergent horizontal nozzles, enthalpy at the entry and exit are 600 kJ/kg and 500 kJ/kg. If the velocity of approach at the inlet is negligible, then the exit velocity of the fluid will be

A. 20 m/s B. 400 m/s
C. 447.2 m/s D. 520.8 m/s

Ans. C

Sol. Given, $v_1 = 0$

Applying steady flow energy equation

$$h_1 + \frac{v_1^2}{2} = h_2 + \frac{v_2^2}{2}$$

Given, $v_1 = 0$

So,

$$h_1 = h_2 + \frac{v_2^2}{2}$$

$$\Rightarrow v_2 = \sqrt{2\times(h_1 - h_2)} = \sqrt{2\times(600000-500000)} = 447.2 \text{ m/s}$$

24. A cylinder whose internal diameter is 10m and thickness 5mm is to be designed such that the maximum volumetric strain does not exceed 5. Calculate the internal pressure to which the cylinder can be subjected to, provided the modulus of elasticity of material is 200GPa and it has a poisson's ratio of 0.3

A. 526.315MPa
B. 426.315 MPa
C. 326.315 MPa
D. 145.256 MPa

Ans. A

Sol. For a cylinder the volumetric strain is given by,

Volume of cylinder = $\frac{\pi}{4}d^2h$

Therefore,

$$e_v = 2e_r + e_l$$

e_v = voumteric strain

e_r = hoop strain

e_l = longitudinal strian

v = poissons ratio

$$e_r = \frac{pd}{2tE}\left(1-\frac{v}{2}\right) \text{ and } e_l = \frac{pd}{2tE}\left(\frac{1}{2}-v\right)$$

Substituting the values in the above equation will give P=526.315MPa

So,

$$e_v = \frac{pd}{2tE}\left(2 - v + \frac{1}{2} - v\right)$$

$$e_v = \frac{pd}{2tE}\left(\frac{5}{2} - 2v\right)$$

$$5 = \frac{p\ X\ 10000}{2\ X\ 5\ X\ 200000}\ X\ (2.5 - 2\ X 0.3)$$

P = 526.315MPa

25. One end of two long, cylindrical rods of the same diameter but different materials, is attached to a base surface maintained at 100°C. The surfaces of the rods are exposed to same ambient condition air at 20°C. By traversing the length of each rod with a thermocouple, it was observed that the temperatures of the rods were equal at the positions x_A = 0.15m and x_B = 0.075m, where x is measured from the base surface. If the thermal conductivity of rod A is known to be k_A = 70W/m-K, the value of k_B for rod B will be.

A. 17.5 W/m-K B. 280 W/m-K
C. 35.5 W/m-K D. 140 W/m-K

Ans. A

Sol. The temperature distribution for the infinite fin has the form

$$\frac{\theta}{\theta_b} = \frac{T(x) - T_\infty}{T_o - T_\infty} = e^{-mx}$$

where $m = \sqrt{\frac{hp}{kA_c}}$ ...(i)

for the two positions prescribed, x_A and x_B, it was observed that

$T_A(x_A) = T_B(x_B)$ or

$\theta_A(x_a) = \theta_B(x_B)$ ...(ii)

since θ_b is identical for both rods, Eq. (i) with the equality of Eq. (ii) requires that

$m_A x_A = m_B x_B$

Substituting for m from Eq. (i) gives

$$\sqrt{\frac{hp}{k_A A_c}} \times x_A = \sqrt{\frac{hp}{k_A A_c}} \times x_B$$

Recognizing that h, p and A_c are identical for each rod and rearranging,

$$k_B = \left[\frac{x_B}{x_A}\right]^2 \times k_A$$

$$k_B = \left[\frac{0.075}{0.15}\right]^2 \times 70 = 17.5 \text{ W/m-K}$$

26. A closely coiled helical spring is cut into two equal parts. What will be the ratio of the deflection of any of the resulting spring to the deflection of the original spring for the same load?

A. 2 B. 1/2
C. 1 D. ¾

Ans. B

Sol.

$$\frac{w.d/2}{\frac{\pi d^4}{32}} = \frac{G.2x/D}{\pi D.n}$$

Thus,

$$x = \frac{8w.D^3.n}{G.d^4}$$

When spring is cut into two equal parts n = $\frac{n}{2}$

It means ratio will become 0.5.

27. A spring having 30 coils and stiffness K is cut into 3 equal parts and arranged them in parallel combination. What will be the effective stiffness of the new system?

A. K/3 B. K/9
C. 3K D. 9K

Ans. D

Sol. Stiffness, $K \alpha \frac{1}{n}$

So, stiffness of each of new spring will be 3K, and when they were arranged in a parallel combination, stiffness will add up.

Hence stiffness of new system will be = 3K + 3K + 3K = 9K

28. What will be the maximum height (in m) to which a can ball will rise, if it is thrown with a velocity of 150 m/s at an angle of 30° with the horizontal?

A. 287 B. 210
C. 387 D. 310

Ans. A

Sol. Given data-

u=150 m/s, θ =30°

maximum height to which the ball will rise,

$$H = \frac{u^2\sin^2(\theta)}{2g} = \frac{150^2\sin^2(30)}{2\times 9.81} = 286.69\ m$$

29. The entry nozzle angle of an elementary Impulse turbine is 30°. For maximal diagram efficiency, calculate the $blade\,speed \left(u/V\right)$ ratio

A. 0.433 B. 0.25
C. 0.567 D. 0.866

Ans. A

Sol. By definition, the condition for maximum diagram efficiency in case of impulse turbine is given by

$$u = \frac{V\cos\alpha}{2}$$

$$\therefore \frac{u}{V} = \frac{\cos 30^\circ}{2} = \frac{\sqrt{3}}{4}$$

30. Which of the following elements has hexagonal closed packing?

A. Titanium B. Nickel
C. Polonium D. Tungsten

Ans. A

Sol. The crystal structure of titanium at ambient temperature and pressure is closed-packed hexagonal structure (α) with a c/a ratio of 1.587

31. In a compound train, there are six gears namely A, B, C, D, E, F which has 20, 60, 30, 80, 25, 75 respectively numbers of teeth.

Calculate the ratio of angular speed of the driven (F) to the driver (A) of the train:

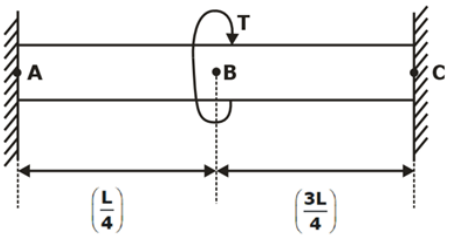
A. 12 B. $\frac{1}{8}$
C. $\frac{4}{15}$ D. $\frac{1}{24}$

Ans. D

Sol. The ratio of angular speeds of F to A :

$$= \frac{T_A \cdot T_C \cdot T_E}{T_B \cdot T_D \cdot T_F} = \frac{20\times30\times25}{60\times80\times75} = \frac{1}{24}$$

32. A torque is applied on a circular shaft as shown below:



[Assume, torsional rigidity of shaft = GJ]

What will be the torques developed at ends A and C respectively?

A. $T_A = \frac{3T}{4}, T_C = \frac{T}{4}$

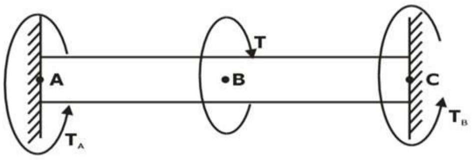
B. $T_A = \frac{T}{4}, T_C = \frac{3T}{4}$

C. $T_A = T_C = T$

D. $T_A = T, T_C = \frac{3T}{4}$

Ans. A

Sol. $T_B = T$ (cw)



Let, T_A and T_C = torques at ends A and C (Acw)

$T_A + T_C = T$ ... (1)

For portion AB: Torque = $T_{AB} = T_A$

For portion BC: Torque = $T_{BC} = T_A - T$

Now, as shaft is fixed at both ends.

∴ Total angular deflection = 0

∴ $\theta_{AB} + \theta_{BC} = 0$

$$\frac{T_{AB} \cdot L_{AB}}{(GJ)} + \frac{T_{BC} \cdot L_{BC}}{(GJ)} = 0$$

[∵ $\theta = \frac{TL}{GJ}$ = angular deflection in shafts]

$$\therefore \frac{T_A\left(\frac{L}{4}\right)}{Gj} + \frac{(T_A - T)\left(\frac{3L}{4}\right)}{GJ} = 0$$

$$T_A\left(\frac{L}{4}\right) + \left(\frac{3L}{4}\right)T_A = \left(\frac{3L}{4}\right)T$$

$$T_A = \frac{3}{4}T$$

From equation (1), $T_A + T_C = T$

$$T_C = \frac{T}{4}$$

33. Which of the following is not true about variance?

A. Var(k) = 0, where k is constant

B. Var(x - k) = Var (x), where k is constant

C. Var(kx) = k^2Var(x), Variance is non-linear

D. Var(ax + by) = a^2Var(x) + Var(y) + abCov(x,y), where Cov = Covariance

Ans. D

Sol. According to the property of variance Var(ax + by) = a^2Var(x) + b^2Var(y) + 2abCov(x,y), where Cov = Covariance

So, the incorrect option is (d).

34. A ball was thrown vertically downwards with an initial velocity of 20m/s from a height of 1.8 m. The ball rebounds from the floor. If e = 0.7, the ball will hit the ceiling at a height of 3.5m with a velocity of;

A. 1.6 m/s B. 16.8 m/s

C. 27.18 m/s D. 29.95 m/s

Ans. B

Sol. Given : u = 20 m/s, S_1 = 1.8 m, S_2 = 3.5 m

∴ $V^2 = u^2 + 2aS$

let, V = ideal velocity after hitting ground

$V^2 = u^2 + 2aS_1$

$V^2 = 20^2 + 2(9.81)(1.8)$

V = 20.86 m/s

V_a = actual velocity after hitting the ground= e*V = 0.7*20.86 = 14.602 m/s

Now, when ball will go up it will strike with the ceiling.

∴ $V_1^2 = V_a^2 + 2aS_2$

where, V_1= velocity with which ball will hit the ceiling

$V_1 = 14.602^2 + 2(9.81)(3.5)$

V_1= 16.789 m/s

35. Given $L^{-1}\left[\frac{4}{s^2+2s}\right]$ find $\lim_{t\to\infty} f(t)$

A. 0 B. 0.5

C. 2 D. 4

Ans. C

Sol. $\lim_{t\to\infty} f(t) = \lim_{s\to 0} s.F(s)$

$= \lim_{s\to 0} \frac{4}{s^2+2s}.s$ = 4/2 = 2

36. A cylinder pin of diameter $1.986^{+0.016}_{-0.006}$ mm is assembled into a hole of diameter $2.000^{+0.0016}_{-0.006}$ mm. Find out the allowance provided in this assembly (in mm).

A. 0.001

B. 0.022

C. 0.025

D. None of the above

Ans. D

Sol. Diameter of Pin = $1.986^{+0.016}_{-0.006}$

Diameter of Hole = $2.000^{+0.0016}_{-0.006}$

By definition, Allowance = Difference b/w Maximum mating limits (MML)

= $H_{shaft} - L_{hole}$

= $(1.986+0.016)-(2-0.006)=0.008\,mm$.

37. The bore and stroke of a single cylinder, four stroke diesel engine are 100 mm and 130 mm respectively and torque is 26 Nm. The brake mean effective pressure of the engine is _____ bar.

A. 1.6 B. 3.2
C. 4.8 D. 6.4

Ans. B

Sol. $BP = \frac{2\pi NT}{60000} = \frac{P_{bm} LAn}{60000}$

$P_{bm} = \frac{2\pi NT}{LAn}$

$= \frac{2\pi NT}{L\times\frac{\pi}{4}D^2\times\frac{N}{2}}$

$= \frac{16T}{LD^2} = \frac{16\times 26}{0.13\times 0.1^2}$

= 3.2 bar

38. The state of stress at a point is given as,

σ_x = 140 MPa

σ_y = 80 MPa

τ_{xy} = 40 MPa

What will be the diameter of the Mohr circle?

A. 120 MPa B. 80 MPa
C. 100 MPa D. 60 MPa

Ans. C

Sol. Radius of Mohr circle = τ_{max}

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

$= \sqrt{\left(\frac{140-80}{2}\right)^2 + (40)^2} = 50$ MPa

Diameter of Mohr circle = 2 *radius =2*50 = 100 MPa

39. If an SI fuel has higher octane number, then it can be concluded that the fuel has:

A. Lower volatility
B. Higher flash point
C. Longer ignition delay
D. Smaller flash point

Ans. C

Sol. An SI fuel with higher octane number will have longer ignition delay, which helps to prevent knocking.

40. It is desired to transport oil at flow speed of 5 m/s having specific gravity 0.9 and viscosity 0.05 poise through a 1.5 m diameter pipe. Experiments were performed on a model of 15 cm diameter pipe using water of specific gravity 1 and viscosity 0.01 poise. The flow velocity in m/s in the model is:

A. 8.7 B. 9
C. 5.5 D. 10.5

Ans. B

Sol. For dynamic similarity, the Reynold's number must be the same for model and prototype:

$\frac{\rho_m V_m D_m}{\mu_m} = \frac{\rho_p V_p D_p}{\mu_p}$

$\frac{1\times V_m\times 15}{0.01} = \frac{0.9\times 5\times 150}{0.05}$

$V_m = 9\,m/s$

41. Air flows past a flat plate at a velocity of 15 m/s where the velocity variation is given by:

$\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$

The plate has a length of 2.5 m and width 1 m. The kinematic viscosity of air is 0.5 stoke. The maximum distance from the leading edge up to which the laminar boundary layer will exist in m is:

A. 1.25 B. 1.67
C. 0.95 D. 2.1

Ans. B

Sol. For a plate, the boundary layer is laminar up to:

$Re = 5\times 10^5$

$Re = \frac{Vx}{\nu}$

$5x10^5 = \frac{15\times x}{0.5\times 10^{-4}}$

$x = 1.667\,m$

42. A car starting from rest, moves with a constant acceleration of 0.7 m/s^2. Determine its velocity in kmph, After it has traveled 50 meters from the point of start.

A. 35 B. 30
C. 45 D. 20

Ans. B

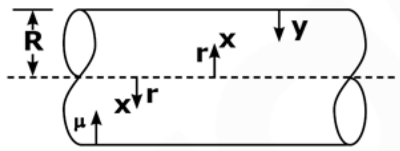
Sol. Given data:
$u=0$, $a=0.7\ m/s^2$, $s=50$ m
we know that, $v^2=u^2+2as=02+2\times0.7\times50$
$=70$
$v=8.36$ m/s$=30.11$ kmph(Ans.)

43. Consider a steady fully, developed flow in a horizontal pipe of diameter D. Over a section of length L of the pipe, a pressure drop of Δp is observed. Wall shear stress for the section is

A. $\frac{\Delta pD}{4L}$ B. $\frac{\Delta pD}{2L}$
C. $\frac{\Delta p\pi L}{2D}$ D. $\frac{\Delta p\pi L}{4D}$

Ans. A

Sol. 2) Velocity distribution:



$R = r + y$
$0 = dr + dy$
$\boxed{dy = -dr}$

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

$\boxed{\tau = \mu\frac{du}{dr}}$ ...(A)

From shear

$\boxed{\tau = \frac{-\partial P}{\partial x}\frac{r}{2}}$ ...(B)

Compare (A) × (B)

$-\mu\frac{du}{dr} = -\frac{\partial P}{\partial x}\frac{r}{2}$

$du = \frac{1}{2\mu}\left(\frac{\partial P}{\partial x}\right)rdr$

Integrating

$u = \frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)r^2 + C$

At r = R, u = 0

$0 = \frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)R^2 + C$

$C = -\frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)R^2$

$u = \frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)r^2 - \frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)R^2$

$= \frac{-1}{4\mu}\left(\frac{\mu P}{\mu x}\right)r^2 + \frac{1}{4\mu}\left(\frac{\partial P}{\partial x}\right)R^2$

$= \frac{-1}{4\mu}\left(\frac{\partial P}{\partial x}\right)[R^2 - r^2]$

44. Assuming $i=\sqrt{-1}$ and t is a real number, $\int_0^{\frac{\pi}{3}} e^{it}dt$ is;

A. $\frac{\sqrt{3}}{2} + i\frac{1}{2}$

B. $\frac{\sqrt{3}}{2} - i\frac{1}{2}$

C. $\frac{1}{2} + i\frac{\sqrt{3}}{2}$

D. $\frac{1}{2} + i\left(1 - \frac{\sqrt{3}}{2}\right)$

Ans. A

Sol. Solution:

$$I = \int_0^{\frac{\pi}{3}} e^{it}\,dt = \left|\frac{e^{it}}{i}\right| = \frac{1}{i}[\cos(t) + \sin(t)]$$

$$= \frac{1}{i}\left|\frac{1}{2} + i\frac{\sqrt{3}}{2} - 1\right|$$

$$= \left[-\frac{1}{2i} + \frac{\sqrt{3}}{2}\right] = \left[\frac{\sqrt{3}}{2} + i\frac{1}{2}\right]$$

45. In case of USM, with increasing mean grain diameter of the abrasive materials, MRR would

A. decrease
B. increase
C. decrease & then increase
D. increase & then decrease

Ans. D

Sol. By definition:
As grain size increase, the chip size removed is increased but after

certain size of grain, it tries to break instead of removing material.

46. The ratio of circumferential strain to longitudinal strain in case of thin pressure vessels is

$$\left[\mu = \frac{1}{m}\right]$$

A. $\frac{2m-1}{m-2}$ B. $\frac{m-2}{2m-1}$

C. $\frac{2-m}{m+2}$ D. $\frac{1-2m}{m-2}$

Ans. A

Sol. For thin pressure vessels,

Circumferential strain, $\varepsilon_C = \frac{pd}{4tE}(2-\mu)$

Longitude strain, $\varepsilon_L = \frac{pd}{4tE}(1-2\mu)$

$$\therefore \left(\frac{\varepsilon_C}{\varepsilon_L}\right) = \frac{(2-\mu)}{(1-2\mu)} = \frac{\left(2-\frac{1}{m}\right)}{\left(1-\frac{2}{m}\right)} = \left(\frac{2m-1}{m-2}\right)$$

$$\left[\text{where, } m = \frac{1}{\mu}\right]$$

47. Find the T_{max} (in Kelvin) for a gas turbine operating on a Brayton cycle if T_{min} = 300 K and the maximum work done per kg of air is 250 kJ/kg.

A. 1095.11K B. 1000.45K

C. 1085.11K D. 1945.45K

Ans. A

Sol. Maximum work for fixed T_{min} and T_{max} is given by:

$$(W_{net})_{max} = C_p(\sqrt{T_{max}} - \sqrt{T_{min}})^2$$

$$250 = 1.005 \times (\sqrt{T_{max}} - \sqrt{300})^2$$

$$\frac{250}{1.005} = (\sqrt{T_{max}} - \sqrt{300})^2$$

On solving,

we get $T_{max} = 1095.11K$

48. Match the following:

1. peritectic reaction	a. S1+L=S2
2. Eutectic reaction	b. L=S2+S3
3. eutectoid reaction	c. S2=S3+S4

A. 1-c,2-b,3-a

B. 1-a,2-c,3-b

C. 1-d,2-b,3-a

D. 1-a,2-b,3-c

Ans. D

Sol.

1. peritectic reaction	a. S1+L=S2
2. Eutectic reaction	b. L=S2+S3
3. eutectoid reaction	c. S2=S3+S4

49. If dynamic load capacity of a ball bearing is 30 kN then, maximum radial load it can sustain to operate at 1200 rpm for 3000 hrs.

A. 5 kN B. 6 kN

C. 8 kN D. 10 kN

Ans. A

Sol. L_{90} = 1200 * 60 * 3000 = 216 million revolutions

For ball bearing,

$$L_{90} = \left(\frac{C}{P}\right)^3$$

$$P = \frac{C}{(L_{90})^{\frac{1}{3}}} = \frac{30}{216^{1/3}} = 5$$

50. How long does it take to accelerate the train to a speed of 90 km/hr from rest having 800 tonnes mass? The resistance to motion is 100 N per tonnes of the train mass and the electric motors can provide 200 kN tractive force.

A. 200 B. 150

C. 133.33 D. 167.67

Ans. D

Sol. Given data:

m=800 t, resistance to motion=100 N/t=100 x 800=80000 N, Tractive force =200 kN, v=90 km/hr=25 m/s and initial velocity u=0

We know that the net force available to move the train

F=Tractive force-resistance to motion

=200-80=120 kN

Acceleration of the train ,a = $\frac{F}{m}$ = (120*1000)/(800*1000)=0.15 m/s^2

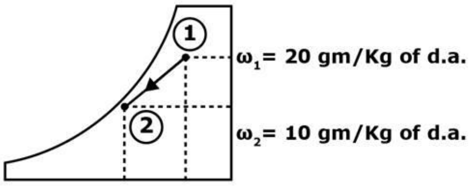
We also know the final velocity of the body

25=u + at

=0 + 0.15 t

Thus t= $\frac{25}{0.15}$ =166.7 s (Ans.)

51. In the psychrometric chart the process (1-2) is given [cooling dehumidification]. Find the percentage change in moisture (initial-final)



A. 40% B. 60%
C. 50% D. 45%

Ans. C

Sol. Since mass of dry air is const. So

$$\% \text{ charge in moisture} = \left(\frac{m_{V_1} - m_{V_2}}{m_{V_1}}\right)$$

$$= \left\{\frac{m_a\omega_1 - m_a\omega_2}{m_a\omega_L}\right\} = \left(\frac{\omega_1 - \omega_2}{\omega_L}\right)\times 100$$

$$= \left(\frac{20-10}{20}\right)\times 100 = 50\%$$

(50% decrease in moisture contain)

52. In case of gears, the phenomenon of interference happens when:

A. Gear tooth are undercut.

B. mating gears pitch are not equal

C. In absence of lubrication, gears tends to not move smoothly.

D. the tip of a mating gear tooth digs into the portion between root & base circles.

Ans. D

Sol. In case of gears, interference takes place when the tip of a tooth of a mating gear digs into the portion between root and base circle.

53. Which of the following properties of refrigerant is not desirable?

A. Low boiling point

B. High critical temperature

C. Specific volume at the inlet of compressor must be high

D. Low Viscosity

Ans. C

Sol. w = $-\int v.dp$

Work input to the compressor is directly dependent upon the volume at the inlet of compressor.

More the volume, more will be the work.

Thus, it is undesirable.

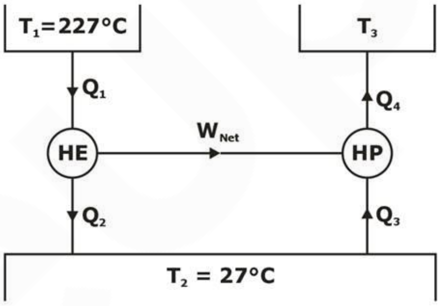
All others are desirable.

54. A reversible heat engine is operated between two thermal reservoir having source and sink temperature 227°C and 27°C respectively and produced work. If this work is supplied to a reversible device which is used to maintain a space higher than the environment temperature. If heat supplied to heat engine is 10 kJ and heat extracted from low temperature reservoir is 8 kJ: Then the temperature of the devised maintained space in (°C)

A. 450°C B. 177°C
C. 227°C D. 327°C

Ans. B

Sol.



T_1 = 227°C = 500 K

T_2 = 27°C = 300 K

T_3 = ?

Q_1 = 10 kJ Q_3 = 8 kJ

$$\eta_{HE} = 1 - \frac{T_L}{T_H} = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \eta_{HE} = 1 - \frac{300}{500} = \frac{2}{5}$$

$$\eta_{HE} = \frac{2}{5} = \frac{W_{Net}}{Q_{supplied}} = \frac{W_{Net}}{Q_1}$$

$$\frac{2}{5} = \frac{W_{Net}}{10} \Rightarrow W_{Net} = 4kJ$$

$$(COP)_{HP} = \frac{DE}{W_{input}} = \frac{Desired\ effect}{Work\ input}$$

$$= \frac{Q_4}{W_{Net}} \quad (Q_4 = Q_3 + W_{Net})$$

$$COP = \frac{Q_3 + W_{Net}}{W_{Net}} = \frac{8+4}{4} = 3$$

$$(COP)_{HP} = \frac{T_3}{T_3 - T_2} = 3 \Rightarrow \frac{T_3}{T_3 - 300} = 3$$

$\Rightarrow T_3$ = 450K

T_3 = 177°C

55. For a simply supported beam under uniformly distributed load of w N/m, deflection at centre is δ. If the same beam is now fixed at both ends under same loading condition, what will be deflection at centre?

A. $\frac{\delta}{5}$ B. $\frac{\delta}{4}$

C. $\frac{\delta}{3}$ D. $\frac{\delta}{2}$

Ans. A

Sol. For simply supported beam with U.D.L,

Deflection at centre is $= \delta = \frac{5wL^4}{384EI}$

Let, δ_1 = deflection at centre of fixed beam under U.D.L

$\therefore \delta_1 = \frac{wL^4}{384EI}$

$\therefore \frac{\delta}{\delta_1} = 5$

$\delta_1 = \frac{\delta}{5}$

56. In a Kaplan turbine, the power developed is 20000 kW under a head of 30 m. The flow ratio is 0.6 and boss diameter is 0.5 times runner diameter. The overall efficiency of the turbine is 80%. The discharge through the turbine is:
Take g=10 m/s^2

A. 84 m^3/s

B. 45 m^3/s

C. 74 m^3/s

D. 67 m^3/s

Ans. A

Sol. The overall efficiency of the turbine is:

$\eta = \frac{P}{Q\rho gH}$

$0.8 = \frac{20000}{Q \times 10 \times 30}$

$Q = 83.33\ m^3/s$

57. Determine the heat rejected in kW from a heat engine functional on Carnot cycle which takes in heat at the pace of 40 kW from a reservoir at 1200 K and rejects it to a sump at 300 K.

A. 30 kW

B. 20 kW

C. 10 kW

D. None of the above

Ans. C

Sol. By definition of Carnot cycle:

$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$

$or,\ Q_2 = \frac{Q_1}{T_1} \times T_2 = \frac{40}{1200} \times 300 = 10\,kW$

58. Taking for granted the general solution of $\frac{t^2d^2y}{dt^2} - \frac{4tdy}{dy} + 6y = 0$ is of the form $y = At^2 + Bt^3$ for appropriate constants A and B, the value of y(2), where y is the solution that also satisfies $y(1) = 2$ and $y'(1) = -1,$ is ________.

A. 10 B. -10

C. 12 D. -12

Ans. D

Sol.

$$y = At^2 + Bt^2$$

$\Rightarrow \quad y(1) = A(1)^2 + B(1)^3$

$\Rightarrow \quad 2 = A + B \quad \ldots(i)$

and, $\quad y' = 2At + 3Bt^2$

$\Rightarrow \quad y'(1) = 2A(1) + 3Bt^2$

$\Rightarrow \quad -1 = 2A + 3B \quad \ldots(ii)$

From (i) and (ii), we get

$$A = 7 \text{ and } B = -5$$

$\therefore \quad y = 7t^2 - 5t^3$

$\Rightarrow \quad y(2) = -12$

59. If young's modulus of elasticity of a material is 140 GPa and Bulk modulus is 70 GPa, what will be the Poisson's ratio (μ)?

A. 0.13 B. 0.15

C. 0.17 D. 0.19

Ans. C

Sol. E = 140 GPa, K = 70 GPa

E = 3K (1 – 2μ)

140 = 3 × 70 × (1 – 2μ)

$\frac{2}{3} = 1 - 2\mu$

$2\mu = \frac{1}{3} \Rightarrow \mu = \frac{1}{6} = 0.167 \cong 0.17$

60. A four-stroke single cylinder IC Engine running at 600rpm has connecting rod of length 150mm and crank of 60mm. What is the maximum shaking force (N) created

by the engine if the mass of reciprocating parts is 2.5kg?
A. 769.40 B. 829.046
C. 900.33 D. 1000

Ans. B

Sol. M = 2.5 kg
R = 60mm
L = 150mm
N = 600rpm
Shaking force
$= MR\omega^2\left(\cos(\theta)+\frac{\cos(2\theta)}{n}\right)$
Maximum shaking force occurs
at $\theta = 0°$
Max. = $Mw^2R(1+1/n)$
n = L/R = 150/60
$= 2.5\ X\ (\frac{2\pi\ X\ 600}{60})^2\ X\ (1+60/150)$ X 0.06
= 829.046N

61. A counter flow heat exchanger is used for heating the water form the air leaving from the exhaust of a power generation plant at 90°C and leaves from the exchanger at 50°C .If water enters at 20°C and get heated to a temperature to 40°C . The logarithmic mean temperature difference for the given heat exchanger in kelvin will be:
A. 312.15 B. 39.15
C. 305.15 D. 32.72

Ans. B

Sol. given,
for hot fluid
T_{hi}=90°C, T_{he}=50°C
for cold fluid
T_{ci}= 20°C T_{ce}=40°C
for counter flow heat exchanger,
$\theta_i = T_{hi} - T_{ce}$ = 90 – 40 = 50
$\theta_i = T_{he} - T_{ci}$ = 50-20= 30
LMTD = $(\theta_i - \theta_o)/\ln(\theta_i / \theta_o)$
= (50 - 30)/ln(50/30)
= 39.15

62. Which of the following is correct regarding the transmission force, damping force and spring force?
A. Transmitted force is the vector sum of damping force and spring force
B. Damping force is the vector sum of transmitted and spring
C. Spring force is the vector sum of transmitted and damping
D. None of these

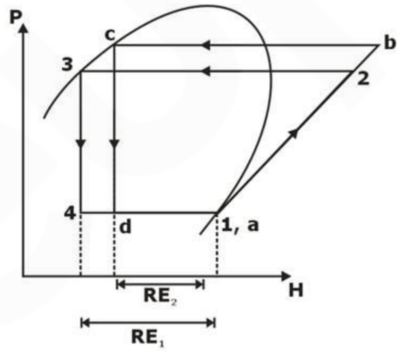
Ans. A

Sol. Transmitted force is the vector sum of damping force and spring force

63. Which of the following is incorrect with respect to increase in condenser pressure?
A. Refrigeration effect will increase
B. volumetric efficiency will decrease
C. work input will increase
D. COP will decrease

Ans. A

Sol.



from the figure
⇒ Refrigeration effect decreases as $RE_1 > RE_2$
⇒ Work input increases as pressure difference increases.

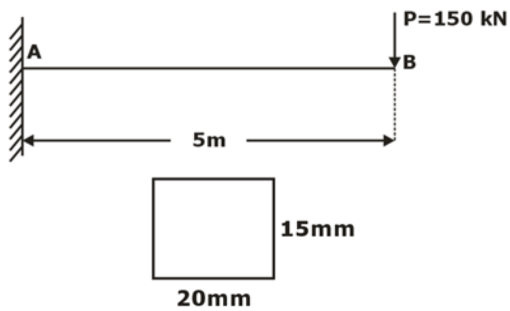
$$\Rightarrow \eta_V = 1 - C\left\{\left(\frac{P_C}{P_E}\right)^{\frac{1}{n}} - 1\right\}$$

volumetric efficiency decreases

$$\Rightarrow COP = \frac{RE}{W_{i/P}} = \frac{\downarrow}{\uparrow}$$

COP = decreases

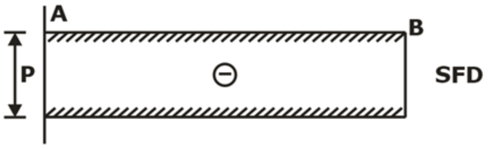
64. For the cantilever beam shown below, calculate the maximum shear stress developed:



A. 450 MPa B. 500 MPa
C. 750 MPa D. 800 MPa

Ans. C

Sol. Shear force diagram of beam will be:



Hence, max shear force acting on beam = P (only magnitude)

As beam is of rectangular cross-section,

∴ max shear stress,

$$\tau_{max} = \frac{3}{2}(\tau_{avg}) = \frac{3}{2}\left[\frac{P}{\text{area of Beam}}\right] = \frac{3}{2}\left[\frac{P}{20\times 15}\right]$$

$$= \frac{3}{2}\times\frac{150\times 10^3}{20\times 15} = 750\,N/mm^2 = 750\text{ MPa}$$

65. The state of a real gas is changed from initial pressure (P_1) and temperature (T_1) to a final state of pressure (P_2) and temperature (T_2), then the enthalpy change of the gas is given by

A. $\int_{T_1}^{T_2} C_p dT$

B. $\int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2}\left(\frac{\partial V}{\partial P}\right)_T dp$

C. $\int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2}\left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] dp$

D. $\int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2}\left[V - T\left(\frac{dV}{dT}\right)_P\right] dp$

Ans. C

Sol. We have

$$Tds = dh - VdP \quad ...(i)$$

$$Tds = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dp \quad ...(ii)$$

Substituting (ii) in (i), we get

$$dh - Vdp = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$$

On rearranging and integrating, we get

$$\Delta h = \int_{T_1}^{T_2} C_p dT + \int_{P_1}^{P_2}\left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] dp$$

66. Select the best options from below, which correctly matches the 'Operating mode of SI engine' (List A) with the 'Desired A/F ratio' (List B):

List A	**List B**
A1: Idling	B1: 13.0
A2: Cold Starting	B2: 4.0
A3: Cruising	B3: 16.0
A4: Full throttle	B4: 9.0

A. A1 - B4, A2 - B2, A3 - B3, A4 - B1
B. A1 - B4, A2 - B2, A3 - B1, A4 - B3
C. A1 - B2, A2 - B4, A3 - B3, A4 - B1
D. A1 - B2, A2 - B4, A3 - B1, A4 - B3

Ans. A

Sol. Idling - 9:1
Cold starting - 4:1
Cruising - 16:1
Full throttle - 13:1

67. The order of convergence of Regula falsi method is

A. 0
B. 1
C. between 1 and 2
D. 2

Ans. C

68. During a rolling process, a sheet of 4mm thick is rolled down to 3 mm thickness. If the roll of diameter 300 mm rotates at 100 rpm, calculate the velocity of strip (in m/s) at the neutral point.

A. 1.57 B. 3.14
C. 47.15 D. 97.25

Ans. A

Sol. Data:

$h_1 = 4\,mm, h_2 = 3\,mm, D = 300\,mm, N = 100\,rpm$

We know that,

At Neutral Point:

$$Velocity\,of\,strip = Surface\,velocity\,of\,rollers$$

$$\therefore V = \frac{\pi DN}{60\times 1000} = \frac{\pi\times 300\times 100}{60\times 1000} = \frac{\pi}{2} = 1.57\,m/s$$

69. For long column of length L, what will be the ratio of $\left(\frac{P_1}{P_2}\right)$;

where,

P_1 = Euler's buckling load, when both ends are hinged.

P_2 = Euler's buckling load, when both ends are fixed.

A. 0.25 B. 0.50
C. 1 D. 4

Ans. A

Sol. $P_1 = \frac{\pi^2 EI}{l_e^2}$; $l_e = L$ (for both ends hinged)

$= \frac{\pi^2 EI}{L^2}$

$P_2 = \frac{\pi^2 EI}{l_e^2}$; $l_e = \frac{L}{2}$ (for both ends fixed)

$\therefore P_2 = \frac{\pi^2 EI}{\left(\frac{L}{2}\right)^2} = \frac{4\pi^2 EI}{L^2} = 4(P_1)$

Hence, $\frac{P_1}{P_2} = \frac{1}{4} = 0.25$

70. Which of the statements given below is/are correct?
1) Pressure angle is defined as the angle between the direction of follower movement & the normal to the base curve at any point.
2) In case of radial translating roller follower, parabolic motion of the follower is very appropriate for high speed cams.
A. Only 1
B. Only 2
C. Both 1 & 2
D. Neither 1 nor 2

Ans. D

Sol. Correct Statements:
1. Pressure angle is defined as the angle between the direction of follower movement & the normal to the 'pitch' curve at any point.
2. For high speed use cycloidal motion.

71. Determine the tangential velocity of steam at the tip of an impulse turbine designed for free vortex flow, if the tangential velocity of steam at the root radius of 250 mm as 430 m/s and the height of blade to be 100 mm.
A. $602\,m/s$
B. $504\,m/s$
C. $409\,m/s$
D. $307\,m/s$

Ans. D

Sol. By definition:

For *freevortex*,

$V.r = \text{constant}$

$\therefore V_1 \cdot r_1 = V_2 \cdot r_2$

$\therefore V_2 = \frac{V_1 \cdot r_1}{r_2} = 430 \times \frac{250}{(250+100)} = 307\,m/s$

72. For angle measurement in Metrology, which of the following pairs given in below alternatives can be best used:
A. Vernier callipers & Sine Bar
B. Slip gauges & Sine Bar
C. Bevell protractor & Slip gauges
D. Bevell protractor & Sine bar

Ans. B

Sol. For setting/measurement of an angle, sine bar is used in concurrence with slip gauges for smaller jobs & height gauges for longer jobs.

73. A vertical hydraulic piston cylinder system has a 125 mm piston diameter and fluid inside the cylinder. An outside ambient pressure of 1 bar is working on piston. Assuming standard gravity, what will be the piston mass that create a inside pressure of 1500 kPa?
A. 2101 kg B. 1489kg
C. 1969 kg D. 1751 kg

Ans. D

Sol. We have,
p_0 = 1 bar = 100 kPa (1 bar = 10^5 Pa)
and

$A = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (0.125)^2 = 0.01227\ m^2$

Force balance on the system gives,
$F_{inside} = F_{outside}$
$pA = p_0 A + m_p g$ where m_p is the mass of the piston.
or

$m_p = (p - p_0)\frac{A}{g}$

$= (1500 - 100) \times 10^3 \times \frac{0.01227}{9.81} = 1751\text{kg}$

74. During a rolling process, a sheet of 25 mm thick is rolled down to 15 mm thickness. If the roll of diameter 800 mm rotates at 200 rpm, calculate the approximate roll strip contact length?
A. 45 mm B. 63 mm
C. 86 mm D. 95 mm

Ans. B

Sol. Data:

$h_1 = 25\,mm, h_2 = 15\,mm, D = 800\,mm, N = 200\,rpm$

Roll strip contact length:

$L = \sqrt{R \cdot \Delta H}$

$\therefore L = \sqrt{400 \times 10} = \sqrt{4000} \approx 63\,mm$

75. Consider a heat engine operative in a cycle between temperature range 756°C to 25°C what will be the lowest rate of heat rejection per kilowatt net output of the prime-mover?

A. 0.52 B. 0.35
C. 0.27 D. 0.41

Ans. D

Sol. Minimum or Least rate of heat rejection per kW output = $\frac{Q_2}{W}$ will only happen, when the process will be reversible.

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2} = \frac{Q_1 - Q_2}{T_1 - T_2} = \frac{W}{T_1 - T_2}$$

$$\Rightarrow or\ \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2} = \frac{298}{1029 - 298} = 0.407$$

76. In a mechanical workshop, while machining of a object on a Shaper machine, a QRR (Quick Return Ratio) of $3/2$ is obtained. If the work-piece is 200 mm long & is machined at a cutting speed of 180 m/min. The crank RPM thus obtained will be approximately:

A. 450 B. 540
C. 820 D. 980

Ans. B

Sol.

$$V = \frac{NL(1+\lambda)}{1000}$$

$$\therefore N = \frac{V \times 1000}{L(1+\lambda)} = \frac{180 \times 1000}{200 \times (1 + 2/3)}$$

= 540rpm

77. The stoichiometric quantity of air, Calculate the air-fuel ratio on molar basis that could come out: Inside an Oil marketing R&D lab, Methane $[CH_4]$ is made to undergo combustion with

A. $15.22:1$
B. $12.30:1$
C. $7.52:1$
D. None of the above

Ans. D

Sol. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

i.e. Mole of O_2 required for 1 Mole of methane are 2

$\therefore$ A/F ratio = $\frac{2}{1} = 2$

78. A turbine generates a power of 19600 kW while operating under a head of 256 m. The turbine runs at 200 rpm. The specific speed of the turbine is:

A. 32.9 B. 42.8
C. 27.3 D. 15.4

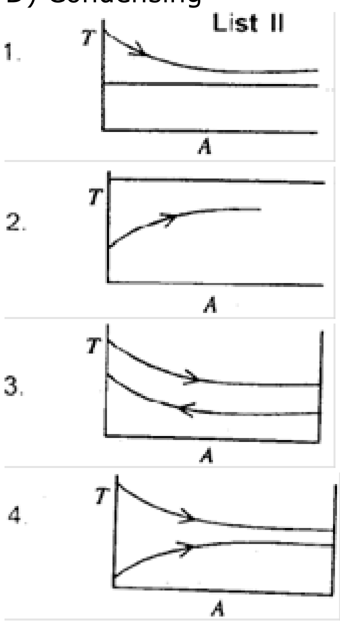
Ans. C

Sol. The specific speed is given by:

$$N_s = \frac{N\sqrt{P}}{H^{1.25}} = \frac{200 \times \sqrt{19600}}{256^{1.25}} = 27.343$$

79. Match List-I (Heat exchanger process) with List-II (Temperature area diagram) and select the correct answer:

List-I
A) Counter flow sensible
B) Parallel flow sensible heating
C) Evaporating
D) Condensing



A. A-3 B-4 C-1 D-2
B. A-3 B-2 C-5 D-1
C. A-4 B-3 C-2 D-5
D. A-4 B-2 C-1 D-5

Ans. A

80. Based on Reynold's experiment the critical Reynold's number for a flow is based on

A. Lower critical velocity

B. Upper critical velocity

C. Average of 'A' and 'B'

D. None

Ans. A

Sol. Based on Reynold's experiment the critical Reynold's number for a flow is based on lower critical velocity.

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