ESE 2020

Paper-2

Mechanical Engineering

Questions & Solutions

MECHANICAL-ENGINEERING-ESE-2020

1. The time taken to face a workpiece of 80 mm diameter for the spindle speed of 90 rpm and cross feed 0.3 mm/rev will be

A. 4.12 min B. 3.24 min

C. 2.36 min D. 1.48 min

Ans. D

Sol. D = 80 mm, N = 90 mm,

f = 0.3 mm/Rev.

for facing length of cut, $l = \left(\frac{D}{2}\right) = 40$ mm

$\therefore$ time taken, $t_m = \left(\frac{l}{fN}\right) = \frac{40}{0.3 \times 90}$

$\boxed{t_m = 1.48 \text{ min}}$

2. A feed f for the lathe operation is

A. $\frac{N}{L \times T_m}$ mm/rev

B. $\frac{L}{N \times T_m}$ mm/rev

C. $\frac{T_m}{N \times L}$ mm/rev

D. $\frac{T_m \times L}{N}$ mm/rev

Ans. B

Sol. Machining time, $t_m = \frac{L}{fN}$

$\therefore \boxed{f = \frac{L}{Nt_m}}$

3. The main advantage of the radial drilling machine is that

A. It is very compatible and handy for machining

B. It is accurate, economical, portable and least time consuming while machining

C. Heavy workpieces can be machined in any position without moving them

D. Small workpieces can be machined and it can b used for mass production as well

Ans. C

Sol. The main advantage of the radial drilling machine is that heavy workpieces can be machined in any position without moving them.

4. For the purpose of sampling inspection, the maximum percent defective that can be considered satisfactory as a process average is

A. Rejectable Quality Level (RQL)

B. Acceptable Quality Level (AQL)

C. Average Outgoing Quality Limit (AOQL)

D. Lot Tolerance Percent Defective (LTPD)

Ans. D

Sol. Lot tolerance percentage defective (LTPD) is the maximum percentage defectives that can be considered satisfactory.

5. Hard automation is also called

A. Selective automation

B. Total automation

C. Group technology

D. Fixed position automation

Ans. D

Sol. Fixed automation is also called fixed position Automation. This kind of machines is used to create specific products with a predefined process.

6. The method of CNC programming which enables the programmer to describe part geometry using variables is

A. Computer assisted part programming

B. Computer aided drafting programming

C. Conversational programming

D. Parametric programming

Ans. A

Sol. In computer-assisted part programming, programming is due by the computer itself and the efforts of the programmer are reduced to large extent.

7. Revolving joint of the robot is referred to as

A. L joint B. O joint

C. T joint D. V joint

Ans. D

Sol. Revolving joint is also called V-joint (for Robots)

8. Repairing of a machine consists of 5 steps that must be performed sequentially. Time taken to perform each of the 5 steps is found to have an experimental distribution with a mean of 5 minutes and is independent of other steps. If these machines break down in Poisson fashion at an average rate of 2 hour and it there is only one repairman, the average idle time for each machine that has broken down will be

A. 120 minutes B. 110 minutes

C. 100 minutes D. 90 minutes

Ans. *

9. A problem of the total float within which an activity can be delayed for start without affecting the floats of preceding activities is called

A. Safety float

B. Free float

C. Independent float

D. Interfering float

Ans. C

Sol. Independent float

= (Free float) – (tail event stack)

Hence, Independent float is that portion of the total float by which an activity can be delayed without affecting the floats of preceding activities.

10. An oil engine manufacturer purchases lubricant cans at the rate of Rs. 42 per piece from a vendor. The requirement of these lubricant cans is 1800 per year. If the cost per placement of an order is Rs. 16 and inventory carrying charges per rupee per year is 20 paise, the order quantity per order will be

A. 91 cans B. 83 cans

C. 75 cans D. 67 cans

Ans. B

Sol. Unit list,

C = 42 per/piece

D = 1800 per year

C_0 = 16 Rs/order

G = 0.2 × C = (0.2× 42) Rs/unit/year

EDQ, $Q* = \sqrt{\frac{2DG}{C}} = \sqrt{\frac{2\times1800\times16}{0.2\times42}} = 82.8 \cong 83$

11. Consider the following data regarding the acceptance sampling process:

N = 10,000, n = 89, c = 2, P = 0.01, and P_a = 0.9397

The Average Total Inspection (ATI) will be

A. 795 B. 687

C. 595 D. 487

Ans. B

Sol. Average total inspection (ATI) = n + (1 – P_a) (N – n) = 89 + (1 – 0.939) (10000 – 89) = 693.57 ≈ 687

12. The Non-Destructive Inspection (NDI) technique employed during inspection for castings of tubes and pipes to check the overall strength of a casting in resistance to bursting under hydraulic pressure is

A. Radiographic inspection

B. Magnetic particle inspection

C. Fluorescent Penetrant

D. Pressure testing

Ans. D

Sol. Pressure testing is a NDT technique used for check whether the pipes and tubes are capable of withstanding its Rated pressure is not and Also to check proofing.

13. Consider the situation where a microprocessor gives an output of an 8-bit word. This is fed through an 8-bit digital to analogue converter to a control valve. The Control valve requires 6.0 V being fully open. If the fully open state is indicated by 11111111, the output to the valve for a change of 1-bit will be

A. 0.061 V B. 0.042 V

C. 0.023 V D. 0.014 V

Ans. C

Sol. the output to the value for a change of 1 bit = Resolution

$$Re\,s\,olution = \frac{full\ scale\ value}{(2^n-1)}$$

$$= \frac{6}{(2^8-1)} = \frac{6}{255}$$

= 0.023V

14. Which of the following factors are to be considered while selecting a microcontroller?

(1) Memory requirements

(2) Processing speed required

(3) Number of input/output pins

A. 1 and 2 only B. 1 and 3 only

C. 2 and 3 only D. 1, 2 and 3

Ans. D

Sol. Factors considered while selecting a micro controller are

i. Processing speed

ii. Memory requirements

iii. Number of I/O ports or pins.

15. Which of the following statements regarding interface circuit are correct?

(1) Electrical buffering is needed when the peripheral operates at a different voltage or current to that on the microprocessor bus system or there are different ground references.

(2) Timing control is needed when the data transfer rates of the peripheral and the microprocessor different.

(3) Changing the number of lines is needed when the codes used by the peripherals differ from those used by the microprocessor.

A. 1 and 2 only B. 1 and 3 only

C. 2 and 3 only D. 1, 2 and 3

Ans. A

Sol. Electric buffering is one that provides electrical impedance transformation from one circuit to another, with the aim of preventing the signal being affected by whatever currents or voltages option 1 is correct.

→ Timing control is needed when the data transfer rates of the peripheral and the microprocessor are different.

Since option 1 and 2 are current.

16. Alternative paths provided by vertical paths from the main rung of a ladder diagram, that is, paths in parallel, represent

A. Logical AND operations

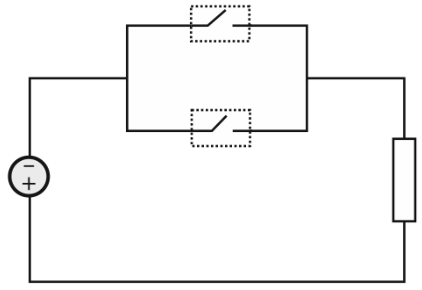
B. Logical OR operations

C. Logical NOT operations

D. Logical NOR operations

Ans. B

Sol. Switching diagram of Logical or operation



Logical OR operation provider paths in parallel.

17. The resolution of an encoder with 10 tracks will be nearly

A. 0.15°   B. 0.25°

C. 0.35°   D. 0.45°

Ans. C

Sol. The resolution of an encoder with 10 tracks

$= \frac{360^\circ}{(2^{10}-1)} = \frac{360^\circ}{1023}$

= 0.35°

18. Which of the following features is/are relevant to variable reluctance stepper motors?

(1) Smaller rotor mass; more responsive

(2) Step size is small

(3) More sluggish

A. 1 only   B. 2 only

C. 3 only   D. 1, 2 and 3

Ans. A

Sol. As the rotor is made up of soft-iron in case of variable reluctance motor, it has small rotor mass, hence it is quick in response.

19. Which of the following statements regarding hydraulic pumps are correct?

(1) The gear pump consists of two close-meshing gear wheels which rotate in opposite directions.

(2) In vane pump, as the rotor rotates, the vanes follow the contours of the casing.

(3) The leakage is more in vane pump compared to gear pump

A. 1, 2 and 3   B. 1 and 2 only

C. 1 and 3 only   D. 2 and 3 only

Ans. B

Sol. As In the vane pump leakage is less as compared to gear pump, so statement 3rd is not true.

20. The selection of the right controller for the application depends on

(1) The degree of control required by the application

(2) The individual characteristics of the plants

(3) The desirable performance level including required response, steady-state deviation and stability.

Which of the above statements are correct?

A. 1 and 2 only   B. 1 and 3 only

C. 2 and 3 only   D. 1, 2 and 3

Ans. D

Sol. 1) The degree of control required by the application.

2) The individual characteristics of the plant.

3) The desirable performance level including response, steady-state deviation and stability.

21. Consider a system described by

$$x = Ax + Bu$$

$$y = Cx + Du$$

The system is completely output controllable if and only if

A. The matrix

$$\left[CB \vdots CBA \vdots CB^2A \vdots \cdots \vdots CB^{n-1}A \vdots D\right]$$

is of rank n

B. The matrix

$$\left[CB \vdots CBA \vdots CA^2B \vdots \cdots \vdots CA^{n-1}A \vdots D\right]$$

C. The matrix

$$\left[BC \vdots BAC \vdots BA^2C \vdots \cdots \vdots BA^{n-1}C \vdots D\right]$$

D. The matrix

$$\left[BC \vdots ABC \vdots CA^2B \vdots \cdots \vdots CB^{n-1}A \vdots D\right]$$

Where :

x = State vector (n-vector)

u = Control vector (r-vector)

y = Output vector (m-vector)

A = n × n matrix

B = n × r matrix

C = m × n matrix

D = m × r matrix

Ans. B

Sol. The system is completely output controllable if and only if

$$\left[CB \vdots CBA \vdots CA^2B \vdots \cdots \vdots CA^{n-1}A \vdots D\right]$$

22. Which one of the following symbols is used as the notation for designating arm and body of a robot with joined arm configuration ?

A. TRL B. TLL, LTL, LVL

C. LLL D. TRR, VVR

Ans. D

Sol. Robot with jointed arm configuration for 3 DOF-robot carries all its joints as revolute. It can be TRR, VRR and other combinations of T, R and V.

23. A complaint motion control of robots can be understood by the problem of controlling of

A. Position and velocity of joints

B. Position and acceleration of the end-effector

C. Manipulator motion and its force interactions with environment

D. Joint velocities of given end-effector velocity

Ans. C

Sol. A compliant motion control of robots can be understood by the problem of controlling of manipulator motion and its force interactions with the environment.

24. For the vector v = 25i + 10j + 20k, perform a translation by a distance 8 in the x-direction, 5 in the y-direction and 0 in the z-direction. The translated vector Hv will be

A. $\begin{bmatrix} 1 \\ 20 \\ 33 \\ 15 \end{bmatrix}$ B. $\begin{bmatrix} 33 \\ 15 \\ 20 \\ 1 \end{bmatrix}$

C. $\begin{bmatrix} 15 \\ 33 \\ 1 \\ 20 \end{bmatrix}$ D. $\begin{bmatrix} 1 \\ 15 \\ 20 \\ 33 \end{bmatrix}$

Ans. B

Sol. Vector offer translation

$= (25+8)\hat{i} + (10+5)\hat{j} + (20+0)\hat{k} \quad = 33\hat{\imath} + 15\hat{\jmath} + 20\hat{k}$

Directions: Each of the next six (06) items consists of two statements, one labelled as 'Statement (I)' and the other labelled as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Code:

A. Both statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).

B. Both statement (I) and Statement (II) are individually true, but statement (II) is not the correct explanation of Statement (I).

C. Statement (I) is true, but Statement (II) is false.

D. Statement (I) is false, but Statement (II) is true.

25. Statement (I): The greater the chemical affinity of two metals, the more restricted is their solid solubility and greater is the tendency of formation of compound.

Statement (II): Wider the separation of elements in the periodic table, greater is their chemical affinity.

Ans. A

Sol. The greater the chemical affinity of two metals the more restricted is their solid solubility and the greater is the tendency towards compound formation thus both the assertion and reason are true and reason is correct explanation of assertion.

26. Statement (I) : The size of a memory unit is specified in terms of the number of storage locations available, 1 K is 2^{10} = 1024 locations and thus a 4 K memory has 4096 locations.

Statement (II) : Erasable and programmable ROM (EPROM) is a form of memory unit used for ROMs that can be programmed and their contents altered.

Ans. B

Sol. In the Binary $2^{10} = 1024 = 1$ k

4k memory mean = $4 \times 1024 = 4096$

EPROM = Erasable programmable ROM (EPROM)

Once programmed, an EPROM can be parsed by exposing UV light.

27. Statement (I) : Microprocessors which have memory and various input/output arrangements, all on the same chip, are called microcontrollers.

Statement (II) : The microcontroller is the integration of a microprocessor with RAM, ROM, EPROM, EEPROM and I/O interfaces, and other peripherals such as timers, on a single chip.

Ans. A

Sol. Microprocessor do contain memory and I/P, O/P on same chip.

Microprocess, memory and I/O designed on same chip are called microcontroller.

28. Statement (I) : Capacitive proximity sensor can only be used for the detection of metal objects and is best with ferrous metals.

Statement (II): One form of capacitive proximity sensor consists of a single capacitor plate probe with the other plate being formed by the object, which has to be metallic and earthed.

Ans. D

Sol. Magnetic field proximity sensors are relatively simple and can be made using a permanent magnet. The magnet can be made a part of object being detected or can be part of the sensor device. It can only be used for the detection of metal object and is best with ferrous metal.

One form of capacitive proximity sensor consists of a single capacitor metallic and earthed figure. As the object approaches so the 'plate separation' of the capacitor changes, becoming significant and detectable when the object is close to the probe.

29. Statement (I) : SCARA configuration provides substantial rigidity for the robot in the vertical direction, but compliance in the horizontal plane.

Statement (II) : A special version of the Cartesian coordinate robot is the SCARA, which has a very high lift capacity as it is designed for high rigidity.

Ans. C

Sol. The SCARA robot is a manipulator with four degrees of freedom. This type of robot has been developed to improve the speed and repeatability ON PICK&PLACE TASKS from one location to another or to speed and improve the steps involved in assembly.

30. **Statement (I) :** The stopper motor is a device that produces rotation through equal angles, the so-called steps, for each digital pulse supplied to its input.

Statement (II) : Stepper motors can be used to give controlled rotational steps but cannot give continuous rotation, as a result their applications are limited to step angles only.

Ans. C

Sol. The stepper motor is a device that produces rotation through equal angles, the so-called steps, for each digital pulse supplied to its input.

Stepper motors can be used to give controlled rotational steps but also can give continuous rotation with their rotational speed controlled by controlling the rate at which pulses are applied to it to cause stepping. This gives a very useful controlled variable speed motor which finds many applications.

31. A stone weighs 400 N in air and when immersed in water it weighs 225 N. If the specific weight of water is 9810 N/m^3, the relative density of the stone will be nearly

A. 5.9 B. 4.7

C. 3.5 D. 2.3

Ans. D

Sol. F_1 = Wt. of stone in Air = 400 N

F_2 = Wt. of stone in water = 225 N

$F_1 - F_2$ = Buoyant force on stone by water

$400 - 225 = (f \forall g) = (f g) \forall$;

[∀ = volume of stone

= displaced volume]

$175 = 9810 \times \forall$ [$fg = 9810\ N/m^3$]

$\forall = 0.01784\ m^3$

$F_1 = f \times \forall \times g$ [f = density of stone]

$\therefore 400 = f \times 0.01784 \times 9.81$

$f = 2285.71\ kg/m^3$

$$\therefore \text{Relative density} = \frac{f}{f_{water}} = \frac{2285.71}{1000}$$
$$= 2.285 \cong (2.3) - (d)$$

32. A flat plate 0.1 m^2 area is pulled at 30 cm/s relative to another plate located at a distance of 0.01 cm from it, the fluid separating them being water with viscosity of 0.001 Ns/m^2. The power required to maintain velocity will be

A. 0.05 W B. 0.07 W

C. 0.09 W D. 0.11 W

Ans. C

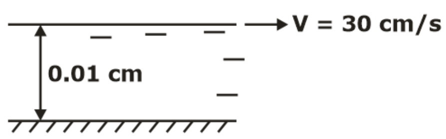
Sol. Area, A = 0.1 m^2

Velocity, v = 30 cm/s = 0.3 m/s

t = distance B/w Plates

= 0.01 cm = (1×10^{-4}) m

μ = 0.01 Ns/m^2



By, Newton's law of viscosity, shear stress (s) $= \frac{\mu V}{t}$

$$s = \frac{0.001 \times 0.3}{1 \times 10^{-4}} = 3\ N/m^2$$

Power,

P = s × Area × velocity

= 3 × 0.1 × 0.3 = 0.09 W

33. When the pressure of liquid is increased from 3 MN/m^2 to 6 MN/m^2, its volume is decreased by 0.1%. The bulk modulus of elasticity of the liquid will be

A. 3×10^{12} N/m^2 B. 3×10^{9} N/m^2

C. 3×10^{8} N/m^2 D. 3×10^{4} N/m^2

Ans. B

Sol. $P_1 = 3$ MN/m^2, $P_2 = 6$ MN/m^2

$$\frac{\delta v}{v} \times 100 = -0.1$$

$$\boxed{\frac{\delta v}{v} = -0.001}$$

Bulk modulus,

$$K = \frac{P_2 - P_1}{-\frac{\delta V}{V}}$$

$$k = 3000 \text{ MN/m}^2$$

$$\boxed{k = 3 \times 10^9 \text{ N/m}^2} \quad \ldots\text{(b)}$$

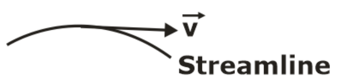
34. A curve that is everywhere tangent to the instantaneous local velocity vector, is

A. Streak line B. Path line

C. Normal line D. Streamline

Ans. D

Sol.



Streamlines at any point are always tangent to the velocity vector at that point i.e. flow is always tangent to streamlines.

35. A 120 mm diameter jet of water is discharging from a nozzle into the air at a velocity of 40 m/s. The power in the jet with respect to a datum at the jet will be

A. 380 kW B. 360 kW

C. 340 kW D. 320 kW

Ans. B

Sol. d = 120 m = 0.120 m

V = 40 m/s^2

$$\text{Power, } P = \text{K.E./sec} = \frac{1}{2}(m)v^2 = \frac{1}{2}(\rho A v)\cdot v^2$$

$$P = \text{K.E./sec} = \frac{1}{2}(m)v^2; (a = \text{area of x} - \text{s/c of jet})$$

$$= \frac{1}{2}(\rho A v)\cdot v^2 = \frac{1}{2}\rho a v^3 = \frac{1}{2} \times 100 \times \left[\frac{\pi}{4}(0.12)^2\right] \times (40)^3$$

$$= 361.91 \times 10^3 \text{ W} = 361.9 \text{ kW} \cong \boxed{362 \text{ kW}}$$

36. Which of the following applications regarding Navier-Stokes equations are correct?

(1) Laminar unidirectional flow between stationary parallel plates.

(2) Laminar unidirectional flow between parallel plates having no relative motion.

(3) Laminar flow in circuit pipes

(4) Laminar flow between concentric rotating cylinders.

A. 1, 2 and 3 only

B. 1, 3 and 4 only

C. 1, 2 and 4 only

D. 2, 3 and 4 only

Ans. A

Sol. Laminar flow between concentric rotating cylinders does not follow Navier-Stokes equation. Hence, statement (4) is incorrect.

37. A crude oil having a specific gravity of 0.9 flows through a pipe of diameter 0.15 m at the rate of 8 lps. If the value of μ is 0.3 Ns/m^2, the Reynolds number will be nearly

A. 295 B. 235

C. 205 D. 165

Ans. C

Sol. Q = 8 lps = 8×10^{-3} m^3/s

$= \left(\frac{\pi}{4}D^2 \times V\right) = \frac{\pi}{4}(0.15)^2 \times v$

V = 0.53 m/s

$R_E = \frac{\rho VD}{\mu}$

$= \frac{(0.9 \times 10^3) \times 0.53 \times 0.15}{0.3}$

R_e = 203.71 ≅ 205

38. Two pipes of lengths 2500 m each and diameters 80 cm and 60 cm respectively, are connected in parallel. The coefficient of friction for each pipe is 0.006 and the total flow is 250 litres/s. The rates of flow in the pipes are nearly

A. 0.17 m^3/s and 0.1 m^3/s

B. 0.23 m^3/s and 0.1 m^3/s

C. 0.17 m^3/s and 0.4 m^3/s

D. 0.23 m^3/s and 0.4 m^3/s

Ans. A

Sol. $l_1 = l_2$ = 250 m

d_1= 80 cm = 0.8 m

d_2 = 60 cm, = 0.6 m

$f_1 = f_2$ = 0.006

Q = 0.25 m^3/s = $Q_1 + Q_2$ ...(1)

For all flow

$R_{f_1} = h_{f_2}$

$\Rightarrow \frac{4f_1 l_1 v_1^2}{2gD_1} = \frac{4f_2 l_2 v_1^2}{2gD_2}$

$\Rightarrow \frac{v_1^2}{D_1} = \frac{v_2^2}{D_2}$

$\Rightarrow \frac{v_1^2}{0.8} = \frac{v_2^2}{0.6}$

⇒ $V_1 = 1.1547\ V_2$

$Q_1 + Q_2 = 0.25$

$\left(\frac{\pi}{4}D_1^2 \times V_1\right) + \left(\frac{\pi}{4}D_2^2 \times V_2\right) = 0.25$

$\frac{\pi}{4}(0.8)^2 \times (1.1547V_2)$

$+\frac{\pi}{4}(0.6)^2 \times V_2 = 0.25$

⇒ V_2 = 0.2896 m/s

$V_1 = 1.1847V_2$

$Q_2 = \frac{\pi}{4}d_2^2 \times V_2 = \frac{\pi}{4}(0.6)^2 \times 0.2896$

= 0.082 m^3/s ≅ 0.1 m^3/s

$Q_1 = \frac{\pi}{4}d_1^2 \times V_1 = \frac{\pi}{4}(0.8)^2 \times (1.1547 \times V_2)$ = 0.168 m^3/s ≅ 0.17 m^3/s

39. A fluid of mass density 1790 kg/m^3 and viscosity 2.1 Ns/m^2 flows at a velocity of 3 m/s in a 6 cm diameter pipe. The head loss over a length 12 m pipe will be nearly

A. 62.0 m B. 54.0 m

C. 46.5 m D. 38.5 m

Ans. D

Sol. ρ = 1790 kg/m^3

μ = 2.1 N s/m^2

V = 3m/sec

D = 6cm = 0.06

$Re = \frac{\rho v D}{\mu} = \frac{1790 \times 3 \times 0.06}{2.1}$

= 153.42

Since, Re < 2000

Laminar flow

$$H = \frac{32\mu VL}{\rho g D^2} = \frac{32 \times 2.1 \times 3 \times 12}{1790 \times 9.81 \times 0.06^2}$$

= 38.26m = 38.5

40. Which of the following characteristics regarding fluid kinematics is/are correct?

(1) Streamline represents an imaginary curve in the flow field so that the tangent to the curve at any point represents the direction of instantaneous velocity at the point.

(2) Path lines, streamlines and streak lines are identical in steady flow.

A. 1 only B. 2 only

C. Both 1 and 2 D. Neither 1 nor 2

Ans. C

Sol. Streamline flow in fluids is defined as the flow in which the fluids flow in parallel layers such that there is no disruption or intermixing of the layers and at a given point, the velocity of each fluid particle passing by remains constant with time. Here, at low fluid velocities, there are no turbulent velocity fluctuations and the fluid tends to flow without lateral mixing. Here, the motion of particles of the fluid follows a particular order with respect to the particles moving in a straight line parallel to the wall of the pipe such that the adjacent layers slide past each other like playing cards Streamline, path line, streak line and timeline form convenient tools to describe a flow and visualise it.

41. To maintain 0.08 m^3/s flow of petrol with a specific gravity of 0.7, through a steel pipe of 0.3 m diameter and 800 m length, with coefficient of friction of 0.0025 in the Darcy relation, the power required will be nearly

A. 0.6 kW B. 1.0 kW

C. 2.6 kW D. 3.0 KW

Ans. B

Sol. f = 0.0025, Q = 0.08 m^3/s

Density of petrol, f = 0.7 × 10^3 = 700 kg/m^3

L = 800 m

D = 0.3 m

∴ h_f = head loss due to friction

$$= \frac{4FLV^2}{2gD} = \frac{4 \times 0.0025 \times 800}{2gD} \times \left(\frac{4Q}{\pi D^2}\right)^2$$

$$= \frac{4 \times 6.0025 \times 800}{2 \times 9.81 \times 0.3} \times \left[\frac{4 \times 0.008}{\pi \times 0.3^2}\right]^2$$

= 1.741 m

Power, P = $\rho g Q(h_f)$

= 700 × 9.81 × 0.008 × 1.741

= 956.43 W = 0.956 kW ≅ 1 kW

42. The diameter of a nozzle d for maximum transmission of power through it, is

A $\left[\frac{D^5}{8fL}\right]^{\frac{1}{4}}$ B. $\left[\frac{D^5}{8fL}\right]^{\frac{1}{2}}$

C. $\left[\frac{8D^5}{fL}\right]^{\frac{1}{4}}$ D. $\left[\frac{8D^5}{fL}\right]^{\frac{1}{2}}$

Where:

D = Diameter of pipe

f = Coefficient of friction

L = Length of pipe

Ans. A

Sol. The diameter of a nozzle d for maximum transmission of power through it

$$d = \left(\frac{D^5}{8fL}\right)^{\frac{1}{4}}$$

43. A piston-cylinder device with air at an initial temperature of 30°C undergoes an expansion process for which pressure and volume are related as given below:

p (kPa)	100	37.9	14.4
V (m^3)	0.1	0.2	0.4

The work done by the system for n = 1.4 will be

A. 4.8 kJ B. 6.8 kJ

C. 8.4 kJ D. 10.6 KJ

Ans. D

Sol. P_1 = 100 kPa P_3 = 14.4 kPa

$V_1 = 0.1\ m^3$ $V_3 = 0.6\ m^3$

∴ WD for (n = 1.4) i.e. for adiabatic process,

$$\delta W = \left[\frac{P_1V_1 - P_2V_2}{n-1}\right] \text{[for a closed system]}$$

$$= \left[\frac{(100\times0.1)-(14.4\times0.4)}{(1.4-1)}\right]\times10^3$$

$= (10.6 \times 10^3)$ J

= 10.6 kJ

44. A domestic food freezer maintains a temperature of −15°C. The ambient air temperature is 30°C. If heat leaks into the freezer at the continuous rate of 1.75 kJ/s, the least power necessary to pump this heat out continuously will be nearly

A. 0.1 kW

B. 0.2 kW

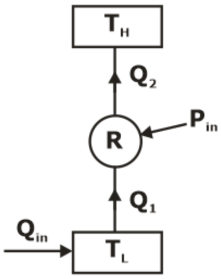
C. 0.3 kW

D. 0.4 kW

Ans. C

Sol. T_L = -15 °C = − 15 + 273 = 258 k

T_H = 30°C= 30 + 273 = 303 k



Heat leakage,

Q_{in} = 1.75 kJ/s = 1.75 kW

Now,

Q_1 = Heat removed from freezer

= Heat leakage = 1.75 kW

Now, for power to be minimum the freezer should be reversible

$$(COP)_{Reversible} = \frac{T_L}{T_H - T_L} = \frac{R_E}{P_{in}} = \frac{Q_1}{P_{in}}$$

$$\Rightarrow \frac{258}{303-258} = \frac{1.75}{P_{in}} \Rightarrow \boxed{P_{in} = 0.305\text{ kW}} \quad ...(c)$$

45. An ideal gas is flowing through an insulated pipe at the rate of 3 kg/s. There is a 10% pressure drop from an inlet to exit of the pipe. The values of R = 0.287 kJ/kg.K and T_o = 300 K. The rate of energy loss for the pressure drop due to friction, will be nearly

A. 34 kW B. 30 kW

C. 26 kW D. 22 kW

Ans. C

Sol. m = 3 kg/s,

$$P_2 = \left[\frac{100-10}{100}\right]P_1 = 0.9\,P_1$$

Rate of energy loss,

= loss in available energy

$= T_0(dS) = T_0(S_2 - S_1)$

$= \left[mRTo\ ln\left[\frac{P_2}{P_1}\right]\right]$

$= 300 \times 3 \times (0.287) \times ln\left[\frac{0.9P_1}{P_1}\right]$

= 27.214 kW

46. A cyclic heat engine operates between a source temperature of 800°C and a sink temperature of 30°C. The least rate of heat rejection per kW net output of engine will be nearly

A. 0.2 kW B. 0.4 kW

C. 0.6 kW D. 0.8 kW

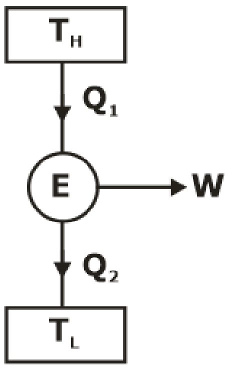
Ans. B

Sol. T_H = 800 °C = 800 + 273

= 1073 k

T_L = 30 °C = 30 + 273 = 303 k

Net output, W = 1 kW



The rate of heat rejection will be minimum, if the heat engine is reversible.

Hence, $(\eta)_{RN} = \left[\frac{T_H - T_L}{T_H}\right] = \frac{W}{Q_1}$

$\therefore \frac{1073 - 303}{1073} = \frac{1}{Q_1}$

Q_1 = 1.3935 kW

$\therefore (Q_2)_{min} = Q_1 - W = 1.3935 - 1$

$= \boxed{0.3935\ kW} \cong \boxed{0.4\ kW}$

47. A fictitious pressure that, if it acted on the piston during the entire power stroke, would produce the same amount of net work as that produced during the actual cycle is called

A. Quasi equivalent pressure

B. Mean equivalent pressure

C. Mean effective pressure

D. Quasi static pressure

Ans. C

Sol. A fictitious pressure that, if it acted on the piston during the entire power stroke, would produce the same amount of net work as that produced during the actual cycle is called Mean effective pressure.

48. An ideal cycle based on the concept of combination of two heat transfer processes, one at constant volume and the other at constant pressure, is called

A. Otto cycle

B. Dual cycle

C. Diesel cycle

D. Carnot cycle

Ans. B

Sol. In Dual cycle, some part of heat addition is done at constant volume and other part of Heat transfer/Addition is done at constant pressure.

49. The ideal thermodynamic cycle for the development of gas turbine engine is

A. Otto B. Stirling

C. Ericsson D. Brayton

Ans. D

Sol. Brayton cycle is the ideal thermodynamic cycle for the development of gas turbine engines.

50. If the pressure at exhaust from the turbine is the saturation pressure corresponding to the temperature desired in the process heater, such a turbine is called

A. Condensing turbine

B. Extraction turbine

C. Pass out turbine

D. Back pressure turbine

Ans. D

Sol. The pressure at exhaust from the turbine is the saturation pressure corresponding to the temperature desired in the process heater, such a turbine is called back pressure turbine.

51. The purpose of providing fins on heat transfer surface is to increase

A. Temperature gradient so as to enhance heat transfer by convection

B. Effective surface area to promote rate of heat transfer by convection

C. Turbulence in flow for enhancing heat transfer by convection

D. Pressure drop of the fluid

Ans. B

Sol. The purpose of providing fins on heat transfer surface is to increase effective surface area to promote rate of heat transfer by convection.

52. For fully developed laminar pipe flow the average velocity is

A. One-half of the maximum velocity

B. One-third of the maximum velocity

C. One-fourth of the maximum velocity

D. Two-third of the maximum velocity

Ans. A

Sol. For fully developed laminar pipe flow, the average velocity is one-half of the maximum velocity.

53. The overall heat transfer coefficient due to convection and radiation for a steam maintained at 200°C running in a large room at 30°C is 17.95 W/m^2K. If the emissivity of the pipe surface is 0.8; the value of σ = 5.67 × 10−8 W/m^2K^4; the heat transfer coefficient due to radiation will be nearly

A. 17 W/m^2K

B. 14 W/m^2K

C. 11 W/m^2K

D. 8 W/m^2K

Ans. C

Sol. Given

$T = 200°C$, $T_\infty = 30°C$, $U = 17.95 \frac{W}{m^2 - K}$

$\in = 0.8$, $\sigma = 5.67 \times 10^{-8}$

$h_{rad} = \in \sigma \left(T_1^2 + T_2^2\right)\left(T_1 + T_2\right)$

$= 0.8 \times 5.67 (473^2 + 303^2)(473 + 303)$

$= 11.10 \ W/m^2K$

$h \simeq 11 \ W/m^2K$

54. Large heat transfer coefficients for vapour condensation can be achieved by promoting

A. Film condensation

B. Dropwise condensation

C. Cloud condensation

D. Dew condensation

Ans. B

Sol. Large heat transfer coefficients for vapour condensation can be achieved by promoting dropwise condensation.

55. Which one of the following valves is provided for starting the engine manually, during cold weather conditions?

A. Starting jet valve

B. Compensating jet valve

C. Choke valve

D. Auxiliary air valve

Ans. C

Sol. Choke valve is used to restrict the Air flow, Hence enriching the fuel-Air mixture while starting the engine manually during cold-weather conditions.

56. A 4-cylinder, 4-stroke single acting petrol engine consumes 6 kg of fuel per minute at 800 rpm when the air-fuel ratio of the mixture supplied is 9 : 1. The temperature is 650 K and pressure is 12.5 bar at the end of compression stroke. Take R = 300 Nm/kg.K, diameter of cylinder as 8 cm, stroke of cylinder as 10 cm. The compression ratio will be nearly

A. 6.2 B. 5.7

C. 5.2 D. 4.6

Ans. *

57. Ice is formed at 0°C from water at 20°C. The temperature of the brine is — 8°C. The refrigeration cycle used is perfect reversed Carnot cycle. Latent heat of ice = 335 kJ/kg, and c_{pw} = 4.18. The ice formed per kWh will be nearly

A. 81.4 kg B. 76.4 kg

C. 71.8 kg D. 68.8 kg

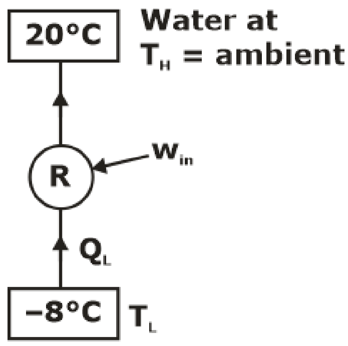
Ans. A

Sol. Water at 20°C → Water at 0°C → ice at 0°

Heat Removed from water to make ice

$Q = C_{Pw}(20 - 0) + 335$

$= 4.18\ (20 - 0) + 335 = 418.6$ kJ/kg



$T_L = -8 + 273 = 265K$

$T_H = 20°C = 20 + 273 = 293K$

W_{in} = 1 kwh = 3600 kJ

$$(COP) = \frac{Q_L}{W_{in}} = \frac{T_L}{T_H - T_L} = \frac{265}{293 - 265} = 9.464$$

$$\frac{Q_L}{3600} = 9.464 \Rightarrow Q_L = 34071.43\ kJ$$

$$\therefore\ m_{ice} = \frac{Q_L}{Q} = \frac{34071.43}{418.6} = 81.39\ Kg$$

58. A Freon 12 simple saturation cycle operates at temperatures of 35°C and — 15°C for the condenser and evaporator. If the refrigeration effect produced by the cycle is 111.5 kJ/kg and the work required by the compressor is 27.2 kJ/kg, the value of COP will be nearly

A. 4.1 B. 3.6

C. 3.1 D. 2.6

Ans. A

Sol. $$(COP) = \frac{RE}{W_{in}} = \frac{111.5}{27.2}$$
$$= 4.099 \cong 4.1$$

59. A cold storage is to be maintained at −5°C while the surroundings are at 35°C. The heat leakage from the surroundings into the cold storage is estimated to be 29 kW. The natural COP of the refrigeration plant used in one-third of an ideal plant working between the same temperatures. The power required to drive the plant will be

A. 10 kW B. 11 kW

C. 12 kW D. 13 kW

Ans. D

Sol. $T_L = -5 + 273 = 268$ K,

$T_h = 35 + 273 = 308$ K

$$\text{Ideal (COP)} = \frac{T_L}{T_H - T_L} = \frac{268}{308-268} = 6.7 \text{ Actual}$$

$$\text{(COP)} = \frac{1}{3}[\text{ideal COP}] = \frac{1}{3} \times 6.7 = 2.233$$

$$\text{Actual COP} = \frac{\text{(Heat leakage)}}{\text{Power input}} = \frac{29}{P_{in}}$$

$$2.233 = \frac{29}{P_{in}}$$

$$\Rightarrow \boxed{P_{in} = 12.98 \text{ kW} \cong 13\text{kW} \quad ...(d)}$$

60. A single acting two-stage air compressor deals with 4 m^3/min of air at 1.013 bar and 15°C with a speed of 250 rpm. The delivery pressure is 80 bar. If the inter cooling is complete, the intermittent pressure after first stage will be

A. 9 bar

B. 8 bar

C. 7 bar

D. 6 bar

Ans. A

Sol. Two stage compression

N = 2

$P_{N+1} = P_D = 80$ bar $P_{in} = 1.013$ bar

$$\frac{P_{N+1}}{P_1} = K^N \Rightarrow \frac{80}{1.013} = (K)^2$$

K = 8.88

$$K = \frac{P_2}{P_1} = 8.88$$

$P_2 = 9.00$ bar

61. Which of the following are the advantages of Nano-composite materials ?

1. Decreased thermal expansion coefficients

2. Higher residual stress

3. Reduced gas permeability

4. Increased solvent resistance

A. 1, 2 and 3 only

B. 1, 3 and 4 only

C. 1, 2 and 4 only

D. 2, 3 and 4 only

Ans. B

Sol. Nano-composites based on Carbon - nanotubes have been used to enhance a wide range of properties, giving rise to functional materials. They have enhanced die-electric properties, thermal resistance, stiffness, strength and wear resistance. Nano-composites will show improved solvent resistance and reduced gas permeability.

62. A rod of copper originally 305 mm long is pulled in tension with a stress of 276 MPa. If the modulus of elasticity is 110 GPa and the deformation is entirely elastic, the resultant elongation will be nearly

A. 1.0 mm B. 0.8 mm

C. 0.6 mm D. 0.4 mm

Ans. B

Sol. $\delta l = \frac{Pl}{AE}$

$$E = \frac{\text{Stress}}{\text{Strain}} = \left(\frac{\sigma l}{\delta l}\right)$$

$$\left(110 \times 10^3\right) = \frac{276 \times 305}{\delta l} \Rightarrow \delta l = 0.7652 \simeq 0.8 \text{ mm}$$

63. A 1.25 cm diameter steel bar is subjected to a load of 2500 kg. The stress induced in the bar will be

A. 200 MPa B. 210 MPa

C. 220 MPa D. 230 MPa

Ans. A

Sol. Stress,

$$\sigma = \frac{\text{Load}}{\text{Area}} = \frac{(250 \times 9.81)}{\frac{\pi}{4} d^2}$$

$$= \frac{2500 \times 9.81}{\frac{\pi}{4}(1.25 \times 10^{-2})^2} = 199.85 \times 10^6 \text{ Pa}$$

$$\cong \boxed{200 \text{ MPa}} \quad \ldots(a)$$

64. The maximum energy which can be stored in a body up to the elastic limit is called

A. Proof resilience

B. Modulus of resilience

C. Impact toughness

D. Endurance strength

Ans. A

Sol. Proof resilience is the maximum amount of energy that can be stored in a specimen up to elastic limits.

65. A cast iron bed plate for a pump has a crack length of 100 μm. If the Young's modulus of cast iron is 210 GN/m^2 and the specific surface energy is 10 J/m2, the fracture strength required will be nearly

A. 1.0×10^8 N/m^2 B. 1.2×10^8 N/m^2

C. 1.4×10^8 N/m^2 D. 1.6×10^8 N/m^2

Ans. D

Sol. a = 100μm

E = 210 GPa G = 10J/m^2

$$\sigma\sqrt{\pi\frac{a}{2}} = \sqrt{EGC}$$

$$\sigma\sqrt{\frac{\pi \times 100 \times 10^{-6}}{2}} = \sqrt{210 \times 10^9 \times 10}$$

$\sigma = 1.6 \times 10^8$ N/m^2

66. A 13 mm diameter tensile specimen has 50 mm gauge length. If the load corresponding to the 0.2% offset is 6800 kg. the yield stress will be nearly

A. 31 kg/mm^2 B. 43 kg/mm^2

C. 51 kg/mm^2 D. 63 kg/mm^2

Ans. C

Sol. $$\text{Yield stress}, \sigma = \frac{6800}{\frac{\pi}{4} \times (13)^2} = 51.25 \text{kg} / \text{mm}^2$$

67. The magnitude of the velocity of any point on the kinematic link relative to the other point on the same kinematic link is the product of

A. A square root of an angular velocity of the link and the distance between the two points under consideration

B. An angular velocity of the link and the square of distance between the two points under consideration

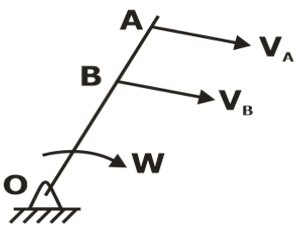
C. A square of an angular velocity of the link and the distance between the two points under consideration

D. An angular velocity of the link and the distance between the two points under-consideration

Ans. D

Sol. The magnitude of the velocity of any point on the kinematic link relative to the other point on the same kinematic link is the product of angular velocity of the link and the distance between the two points under consideration.

$\overrightarrow{V_{AB}}$ = Velocity of Point 'A' w.r.t. **Point 'B'**



$\vec{V}_A - \vec{V}_B - = w(OA) - w(OB)$

$= w[OA - OB] = w[AB]$ ...(d)

68. In a mechanism, the number of Instantaneous centre (I-centres) N is

A. $\frac{n(n-1)}{2}$ B. $\frac{2(2n-1)}{2}$

C. $\frac{2n(n-1)}{3}$ D. $\frac{n(2n-1)}{3}$

where : n = Number of links

Ans. A

Sol. Number of links $n_{C_2} = \frac{n(n-1)}{2}$

69. In cycloidal motion of cam follower, the maximum acceleration of follower motion f_{max} at $\theta = \frac{\phi}{4}$

A. $\frac{h\pi\omega^2}{2\phi^2}$ B. $\frac{3h\pi\omega^2}{2\phi^2}$

C. $\frac{2h\pi\omega^2}{\phi^2}$ D. $\frac{3h\pi\omega^2}{\phi^2}$

h = Maximum follower displacement

ω = Angular velocity of cam

φ = Angle for the maximum follower displacement for cam rotation

Ans. C

Sol. In cycloidal motion

Displacement of follower

$$x = h\left[\frac{\theta}{\theta_0} - \frac{1}{2\pi}\sin\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$V = \frac{dx}{d\theta}.\frac{d\theta}{dt}$$

$$= \omega h\left[\frac{1}{\theta_0} - \frac{1}{2\pi}\cos\left(\frac{2\pi\theta}{\theta_0}\right)\frac{2\pi}{\theta_0}\right]$$

$$= \frac{\omega h}{\theta_0}\left[1 - \cos\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$a = \frac{dV}{d\theta}.\frac{d\theta}{dt} = \frac{\omega^2.h}{\theta_0}\sin\left(\frac{2\pi\theta}{\theta_0}\right).\frac{2\pi}{\theta_0}$$

$$= \frac{2\pi\omega^2.h}{\theta_0^2}\sin\left(\frac{2\pi\theta}{\theta_0}\right)$$

At $\theta = \left(\frac{\phi}{4}\right) = \left(\frac{\theta_0}{4}\right)$ (Here $\theta_0 = \varphi$)

$$(a)_{at\,\theta=\phi/4} = \frac{2\pi\omega^2.h}{\phi^2}$$

70. A shaft of span 1 m and diameter 25 mm is simply supported at the ends. It carries a 1.5 kN concentrated load at mid-span. If E is 200 GPa, its fundamental frequency will be nearly

A. 3.5 Hz

B. 4.2 Hz

C. 4.8 Hz

D. 5.5 Hz

Ans. D

Sol. L = 1m, d = 25 mm

W = 1.5 kN E = 200 GPa

$$\Rightarrow \quad \delta = \frac{WL^3}{48EI}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{g}{\delta}} = \frac{1}{2\pi}\sqrt{\frac{g \times 48EI}{WL^3}}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{9.81 \times 48 \times 200 \times 10^9 \times \pi \times (0.025)^4}{64 \times 1500 \times 1}}$$

f_n = 5.5 Hz

71. A vibrating system consists of mass of 50 kg, a spring with stiffness of 30 kN/m and a damper. If damping is 20% of the critical value, the natural frequency of damped vibrations will be

A. 16 rad/s B. 20 rad/s

C. 24 rad/s D. 28 rad/s

Ans. C

Sol. m = 50 kg k = 30 kN/m ξ = 0.2

$$\omega_d = \sqrt{1-\xi^2}\ \omega_n$$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{30 \times 1000}{50}} =$$

$$\omega_d = \sqrt{(1-(0.2)^2)} \times \sqrt{\frac{30 \times 1000}{30}}$$

ω_d = 24 rad/s

72. A refrigerator unit having a mass of 35 kg is to be supported on three springs, each having spring stiffness s. The unit operates at 480 rpm. If only 10% of the shaking force is allowed to transmit to the supporting structure, the value of stiffness will be nearly

A. 2.7 N/mm B. 3.2 N/mm

C. 3.7 N/mm D. 4.2 N/mm

Ans. A

Sol. Given m = 35 kg

N = 480 rpm ω = 16π

ξ = 0

ϵ = 0.1

S_{eq} = 3s (due to parallel connection)

$$\epsilon = 0.1 = \frac{\sqrt{1+(2\xi\omega/\omega_n)^2}}{\sqrt{\left\{1-\left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

$$0.1 = \frac{1}{\left(\frac{\omega}{\omega_n}\right)^2 - 1} \quad \text{or} \quad \frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}$$

$$10 = \left(\frac{\omega}{\omega_n}\right)^2 - \Rightarrow \left(\frac{\omega}{\omega_n}\right)^2 = 11$$

$$\frac{\omega}{\omega_n} = \sqrt{11} \Rightarrow \frac{16\pi}{\omega_n} = \sqrt{11}$$

$$\omega_n = \sqrt{\frac{3s}{m}}$$

$$\frac{16\pi}{\sqrt{11}} = \sqrt{\frac{3s}{m}} = \sqrt{\frac{3s}{35}}$$

⇒ s = 2679.74 N/m

s = 2.679 N/mm ≈ 2.7 N/mm

73. In which one of the following tooth profiles, does the pressure angle remain constant throughout the engagement of teeth?

A. Cycloidal B. Involute

C. Conjugate D. Epicycloid

Ans. B

Sol. In involute profile tooth, because of the involute property to be satisfied, pressure angle does not change with point of contact position.

74. If the axes of the first and last wheels of a compounded gear coincide, it is called

A. Simple gear train B. Compound gear train

C. Epicyclic gear train D. Reverted gear grain

Ans. D

Sol. Reverted gear train is that compound gear train, which is used to connect co-axial shafts.

75. In a reciprocating engine, the force along the connecting rod F_Q is

A. $\frac{F_P}{\sqrt{n^2 - \sin^2\theta}}$ B. $\frac{F_P}{2\sqrt{n^2 - \sin^2\theta}}$

C. $\frac{nF_P}{2\sqrt{n^2 - \sin^2\theta}}$ D. $\frac{nF_P}{\sqrt{n^2 - \sin^2\theta}}$

F_P = Force on piston

$n = \frac{L}{r}$

θ = Angle for crank from IDC

Ans. D

Sol. $\sin\beta = \frac{\sin\theta}{n}$

Here, $\cos\beta = \sqrt{1 - \frac{\sin^2\theta}{n^2}} = \frac{\sqrt{n^2 - \sin^2\theta}}{n}$

$F_p = F_Q \cos\beta$

$$F_Q = \frac{F_p}{\cos\beta} = \frac{F_p}{\sqrt{\frac{n^2 - \sin^2\theta}{n}}} = \frac{nF_p}{\sqrt{n^2 - \sin^2\theta}}$$

76. A mass m_1 attached to a shaft at radius r_1, rotating with angular velocity ω rad/s, can be balanced by another single mass m_2 which is attached to the opposite side of the shaft at radius r_2, in the same plane, if

A. $m_1r_2 = m_2r_1$ B. $m_1r_2 = m_2r_2$

C. $m_1r_1\omega_1 = m_2r_2\omega_2$

D. $m_1r_2\omega_1 = m_2r_1\omega_2$

Ans. B

Sol. For static balancing,

$m_1r_1=m_2r_2$

77. For a single cylinder reciprocating engine speed is 500 rpm, stroke is 150 mm, mass of reciprocating parts is 21 kg; mass of revolving parts is 15 kg at crank radius. If two-thirds of reciprocating masses and all the revolving masses are balanced, the mas at a radius of 150 mm will be

A. 7.5 kg

B. 10.5 kg

C. 12.5 kg

D. 14.5 kg

Ans. D

Sol. N = 500 rpm L = 150 mm

$r = \frac{L}{2} = 75\text{ mm}$

$M_{Rec} = 21\text{ kg}$ M_R = 15 kg

$$M_{Balance} = M_R + \frac{2}{3}M_{Rec} = 15 + \frac{2}{3} \times 21$$

M_{bal} = 29 kg

B.b = $M_{bal} \times r$

$B \times 150 = 29 \times \frac{150}{2}$

B = 14.5 kg

78. If the axes of the rolling of the ship and of the stabilizing rotor are parallel, it will result in

A. A higher bow and lower stern

B. A lower bow and higher stern

C. Turning towards left

D. No gyroscopic effect

Ans. D

Sol. If the axes of the rolling of the ship and of the stabilizing rotor are parallel then, there will be no effect of gyroscopic couple.

79. Coaxing is a process of

A. Improving the fatigue properties attained by under-stressing and then raising the stress in small increments

B. Decreasing the hardness by full annealing

C. Increasing the uniaxial tensile strength by heating above recrystallization temperature and quenching in oil media

D. Maintaining the ductility of the material by chemical treatment.

Ans. A

Sol. Coaxing is a process of Improving the fatigue properties, attained by under-stressing and then raising the stress in small increments.

80. According to the distortion-energy theory, the yield strength in shear is

A. 0.277 times the yield stress

B. 0.377 times the maximum shear stress

C. 0.477 times the yield strength in tension

D. 0.577 times the yield strength in tension

Ans. D

Sol. According to the distortion-energy theory, the yield strength in shear is $\frac{1}{\sqrt{3}} = 0.577$ times the yield strength in tension.

81. For the prediction of ductile yielding, the theory of failure utilized is

A. Maximum strain energy theory

B. Distortion energy theory

C. Maximum normal strain theory

D. Mohr theory

Ans. B

Sol. For the prediction of ductile yielding, the theory of failure utilized is maximum distortion energy theory which gives the optimum dimensions for any component.

82. A steel specimen is subjected to the following principal stresses: 120 MPa tensile, 60 MPa tensile and 30 MPa compressive. If the proportionality limit for the steel specimen is 250 MPa; the factor of safety as per maximum shear stress theory will be nearly

A. 1.3 B. 1.7

C. 2.3 D. 2.7

Ans. B

Sol. $\sigma_1 = +120$ MPa

$\sigma_2 = +60$ MPa

$\sigma_3 = -30$ MPa

$S_{yt} = 250$ MPa

$$\tau_{abs} = \frac{\sigma_1 - \sigma_3}{2} = \frac{120-(-30)}{2} = 75$$

$$(\tau_{abs}) \le \frac{S_{yt}}{2N} \text{ or } \frac{S_{ys}}{N}$$

$$75 \le \frac{250}{2N}$$

$$N = \frac{125}{75} = \frac{5}{3} = 1.66$$

$N \approx 1.7$

83. For which one of the following loading conditions is the standard endurance strength multiplied by a load factor, $K_e = 0.9$?

A. Reversed beam bending loads

B. Reversed axial loads with no bending

C. Reversed axial loads with intermediate bending

D. Reversed torsion loads

Ans. C

Sol. Standard endurance strength multiplied by a load factor, $K_e = 0.9$ is defined for reversed axial loading with intermediate bending.

84. A 120 mm wide uniform plate is to be subjected to a tensile load that has a maximum value of 250 kN and a minimum value of 100 kN. The properties of the plate material are : endurance limit stress is 225 MPa yield point stress is 300 MPa. If the factor of safety based on yield point is 1.5, the thickness of the plate will be nearly.

A. 12 mm B. 14 mm
C. 16 mm D. 18 mm

Ans. A

Sol. b = 120 mm P_{max} = 250 kN

P_{min} = 100kN

σ_e = 225 MPa, σ_{yt} = 300 MPa

N = 1.5

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

$$\sigma_m = \frac{P_{max} + P_{min}}{2A} = \frac{175}{A}$$

$$\sigma_v = \frac{P_{max} - P_{min}}{2A} = \frac{75}{A}$$

$$\frac{1}{1.5} = \frac{175}{A \times 300} + \frac{75}{A \times 225}$$

A = 1375 mm^2 = bt

1375 = 120 × t

t = 11.45 mm

t ≈ 12 mm

85. A steel connecting rod having S_{ut} = 1000 MN/m2, Syt = 900 MN/m2 is subjected to a completely reversed axial load of 50 kN. By neglecting any column action, if the values of k_e = 0.85, k_b = 0.82, k_t = 1.5 q 0.6 and N 2, the diameter of the rod will be nearly

A. 20 mm B. 23 mm

C. 26 mm D. 29 mm

Ans. B

Sol. S_{ut} = 1000 MPa, S_{yl} = 900 MPa P = 50 kN

σ_e = ka × kb × kc × kd × σe *

σ_e = 0.82 × 0.9 × 0.85 × 0.769 × 500 = 241.19 MPa

in case of steel:

$\sigma_e = \sigma_{ut}/2$ =1000/2 = 500 MPa

$$q = \frac{k_f - 1}{k_t - 1}$$

$$0.6 = \frac{k_f - 1}{1.5 - 1}$$

k_f = 1.3

By Goodman equation,

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

$$\frac{50000}{A \times 241.19} + \frac{0}{\sigma_{ut}} = \frac{1}{2}$$

$$A = \frac{\pi d^2}{4} = 509.409 \text{ mm}^2$$

d = 22.97 mm =23 mm

86. During crushing or bearing failure of riveted joints

A. The holes in the plates become oval shaped and joints become loose

B. There is tearing of the plate at an edge

C. The plates will crack in radial directions and joints fail

D. The rivet heads will shear out by applied stress

Ans. A

Sol. During crushing or bearing failure of riveted joint, the holes in the plate becomes oval shaped and joints become loose.

87. The double riveted joint with two cover plates for boiler shell is 1.5 m in diameter subjected to steam pressure of 1 MPa. If the joint efficiency is 75% allowable tensile stress in the plate is 83 MN/m^2, compressive stress is 138 MN/m^2 and shear stress in the rivet is 55 MN/m^2, the diameter of rivet hole will be nearly

A. 8 mm B. 22 mm
C. 36 mm D. 52 mm

Ans. B

Sol. In case of Boiler steel thickness (t) = $\frac{PD}{2\sigma_t\eta}$

$$t = \frac{1\times1.5\times10^3}{2\times83\times0.75}$$

t = 12.048 mm

$d = 6\sqrt{t}$ when $t \geq 8mm$

$= 6\sqrt{12.048}$

= 20.82 mm

≈ 22 mm

88. A bearing supports a radial load of 7000 N and a thrust load of 2100 N. The desired life of the ball bearing is 160 × 10^6 revolutions at 300 rpm. If the load is uniform and steady, service factor is 1, radial factor is 0.65, thrust factor is 3.5, k = 3 and rotational factor is 1, the basic dynamic load rating of a bearing will be nearly

A. 65 kN B. 75 kN
C. 85 kN D. 95 kN

Ans. A

Sol. P_r = 7000 N, P_a = 2100 N

L_{90} = 160 × 10^6 rev.

N = 300 rpm, C_S = 1

Equivalent radial load, Req. = X.V.P_r + Y.P_a

= 0.65 × 1 × 7000 + 3.5 × 2100

$$L_{90} = \left(\frac{C}{Req}\right)^3 \times 10^6$$

$$(160)^{1/3} = \frac{C}{11900}$$

C = 64.603 KN≈ 65 KN

89. A solid cast iron disk, 1 m in diameter and 0.2 m thick is used as a flywheel. If is rotating at 350 rpm. It is brought to rest in 1.5 s by means of a brake. It the mass density of cast iron is 7200 kg/m3, the torque exerted by the brake will be nearly

A. 3.5 kN m B. 4.5 kN m
C. 5.3 kN m D. 6.3 kNm

Ans. A

Sol. D = 1m, t = 0.2m, N = 350 rpm

T = 1.5 sec, ρ =7200 kg/m^3

$\omega = \omega_0 + \alpha t$

$$0 = \frac{2\times\pi\times350}{60} - \alpha\times1.5 \Rightarrow \alpha = 24.43$$

T = Iα

$$I = \frac{MR^2}{2}$$

$$m = \rho V = 7200\times\frac{\pi}{4}D^2\times t$$

$$= 7200\times\frac{\pi}{4}\times(1)^2\times0.2$$

m = 360π

$$I = \frac{MR^2}{2} = \frac{360\times\pi\times(0.5)^2}{2} = 45\pi$$

T = Iα = 45π × 24.43

T = 3.453 kNm ≈ 3.5 kNm

option (A)

90. The torque transmitting capacity of friction clutches can be increased by

A. Use of friction material with a lower coefficient of friction

B. Decreasing the mean radius of the friction disk

C. Increasing the mean radius of the friction disk

D. Decreasing the plate pressure

Ans. C

Sol. The torque transmitting capacity of friction clutches can be increased by Increasing the mean radius of the friction disk.

91. The ideal gas-refrigeration cycle is the same as the

A. Brayton cycle

B. Reversed Brayton cycle

C. Vapour compression refrigeration cycle

D. Vapour absorption refrigeration cycle

Ans. B

Sol. Reversed Brayton cycle is the ideal-gas Refrigeration cycle.

92. If the atmospheric conditions are 20° C, 1.013 bar and specific humidity of 0.0095 kg/kg dry air, the partial pressure of vapour will be nearly

A. 0.076 bar B. 0.056 bar
C. 0.036 bar D. 0.016 bar

Ans. D

Sol. specific humidity is given by,

$$w = 0.0095 = \frac{0.622 P_v}{(P - P_v)} = \frac{0.622 P_v}{(1.013 - P_v)}$$

$1.013 \times P_v = 65.473\ P_v$

$\boxed{Pv = 0.01524 \text{ bar} \cong 0.016 \text{ bar}}$

93. In air-conditioning systems, air may be cooled and dehumidified by

1. Spraying chilled water to air in the form of fine mist.

2. Circulating chilled water or brine in a tube placed across the air flow.

3. Placing the evaporator coil across the air flow.

Which of the above statements are corrects?

A. 1 and 2 only B. 1 and 3 only
C. 2 and 3 only D. 1, 2 and 3

Ans. C

Sol. If we spray chilled water to Air in form of fine mist then, air will be humidified. But we Need dehumidification.

Hence, option (i) is wrong.

Air may be cooled and dehumidified by circulating chilled water or brine in a tube placed across the air flow and by placing the evaporator coil across the air flow.

So, 2 & 3 are correct.

94. A duct of rectangular cross-section 600 mm × 400 mm carries 90 m3/ min of air having density of 1.2kg/m3. When the quantity of air in both cases is same, the equivalent diameter of a circular duct will be nearly

A. 0.86 m

B. 0.76 m

C. 0.64 m

D. 0.54 m

Ans. D

Sol. Equivalent diameter,

$$d = \frac{4Ac}{P} = \frac{4 \times (\text{Area of x-s/c})}{\text{perimeter}}$$

$$= \frac{2ab}{a+b} = \frac{2 \times 0.6 \times 0.4}{0.6 + 0.4} = 0.48\,\text{m}$$

Nearest answer will be option D.

95. A room having dimensions of 5 m × 5 m × 3 m contains air at 25° C and 100 kPa at a relative humidity of 75%. The corresponding value of p_s is3.169 kPa. The partial pressure of dry air will be nearly

A. 106 kPa B. 98 kPa

C. 86 kPa D. 78 kPa

Ans. B

Sol. P = 100 kPa, P_S = 3.169 kPa

$$\phi = 0.75 = \frac{P_v}{P_s}$$

$$0.75 = \frac{P_v}{3.16} \Rightarrow \boxed{P_v = 2.37675\ \text{kPa}}$$

Partial pressure of dry Air

$= P_a = P - P_v = 100 - 2.37675$

$= 97.623$ kPa ≅ 98 kPa

96. A measure of feeling warmth or coolness by the human body in response to the air temperature, moisture content and air motion is called

A. Dry bulb tempter

B. Effective temperature

C. Wet bulb temperature

D. Dew point temperature

Ans. B

Sol. Effective temperature is a measure of feeling warmth or cooled by human body in Response to the Air temperature, Moisture content and Air motion.

97. While designing a Pelton wheel, the velocity of wheel 'u' is

A. $K_u\sqrt{gH}$ B. $2K_u\sqrt{gH}$

C. $K_u\sqrt{2gH}$ D. $2K_u\sqrt{2gH}$

where:

K_u = Speed ratio

H = Net head on turbine

g = Gravity

Ans. C

Sol. Velocity of wheel,

$$\boxed{u = k_u \times \sqrt{2gH}}$$

98. The turbines of the same shape will have the same

A. Thomas number B. Reynolds number

C. Specific speed D. Rotational speed

Ans. C

Sol. The turbines of same shape and dimensions will have same specific speed.

99. A centrifugal pump is required to lift 0.0125 m^3/s of water from a well with depth 30 m. If rating of the pump motor is 5 kW, and the density of water is 1000 kg/m^3, the efficiency of the pump will be nearly

A. 82%

B. 74%

C. 66%

D. 58%

Ans. B

Sol. Q = 0.0125 m^3/s, H_m = 30 m,

Rating, P = 5 kW = Shaft power

$\rho = 1000\ kg/m^3$

Water power [Manometric power]

$= \rho g Q H_m$

$= 10^3 \times 9.81 \times 0.0125 \times 30$

$= 3.6787 \times 10^3$ W = 3.6787 kW

∴ Efficiency of Pump,

$$\eta = \frac{\text{Water Power}}{\text{Shaft power}} = \frac{3.6787}{5}$$

= 0.7357

= 73.57% ≅ 74%

100. An inward flow reaction turbine has an external diameter of 1 m and its breadth at inlet is 250 mm. If the velocity of flow at inlet is 2 m/s and 10% of the area of flow is blocked by blade thickness, the weight of water passing through the turbine will be nearly

A. 10 kN/s
B. 14 kN/s
C. 18 kN/s
D. 22 kN/s

Ans. B

Sol. External dia, D_1 = 1m,

B_1 = Breath = 250 mm = 0.25 m,

Velocity of flow, $V_{f_1} = 2\,m/s$,

Rate of flow Between vanes,

Q = ($\pi D_1 B_1 \times V_{f1}$) × 0.9

⇒ Q = (π × 1 × 0.25 × 2 × 0.9)

= 1.4137 m^3/sec

∴ Weight of water passing through turbine vanes

= ρQg = 1.4137 × 1000 × 9.81

= 13.87 × 10^3 N/s

= 13.87 kN/s ≅ 14 kN/s

101. The process of abstracting steam at a certain section of the turbine and subsequently using it for heating feed water supplied to the boiler is called

A. Reheating
B. Regeneration
C. Bleeding
D. Binary vapour cycle

Ans. B

Sol. Regeneration is the process of abstracting stream at a certain section of the steam turbine and subsequently using it for heating feed water to the boiler.

102. When blade speed ratio is zero, no work is done because the distance travelled by the blade is zero even if the torque on the blade

A. is minimum

B. is zero

C. is maximum

D. remains the same

Ans. C

Sol. Blade speed Ratio,

$$k_u = \frac{u}{\sqrt{2gH}}$$

If, k_u = 0

⇒ u = 0 = tangential speed = rω

⇒ ω = 0 = angular speed

as, work done = (torque) × ω

if, ω = 0

work done = 0

(What so ever be the value of torque)

103. In an axial flow turbine, the utilization factor has an absolute maximum value of unity, for any degree of reaction if the value of nozzle angle α is

A. 270°
B. 180°
C. 90°
D. 0°

Ans. D

Sol. Utilization factor, for all value of degree of reaction is unity at nozzle angle, α = 0°. and it becomes zero, at nozzle, (α = 90°)

104. Which of the following are essential for a good combustion chamber of turbojet engine?

1. It should allow complete combustion of fuel.

2. It should maintain sufficiently high temperatures in the zone of combustion in addition to proper atomization of fuel thus leading to continuous combustion.

3. It should not have high rate of combustion.

4. The pressure drop should be as small as possible.

A. 1, 2 and 4 only B. 1, 2 and 3 only

C. 1, 3 and 4 only D. 2, 3 and 4 only

Ans. A

Sol. Statement (3) is wrong.

- Turbojet engine should have High rate of combustion.
- It should maintain high temperatures in the zone of combustion to ensure continuous combustion.
  The pressure drop should be as small as possible in the combustion chamber of turbojet engine.

105. If m_f is the mass of fuel supplied per kg of air in one second, then the mass of gases leaving the nozzle of turbojet will be

A. $(1 - m_f)$ kg/s

B. $\frac{1}{(1+m_f)}$ kg/s

C. $(1 + m_f)$ kg/s

D. $\frac{1}{(1-m_f)}$ kg/s

Ans. C

Sol. For turbojet engine, total mass of gases coming out will be sum of fuel and air supplied.

Hence, mass of gases leaving the nozzle of turbojet = $m_{final} = (1+m_f)$ kg/s

106. Which one of the following may be considered as a single cylinder two-stroke reciprocating engine running at 2400 rpm to 2700 rpm for rapid chain of impulses?

A. Turbo jet B. Pulse jet

C. Ram jet D. Athodyd jet

Ans. B

Sol. Pulse jet engine works on single cylinder two-stroke reciprocating engine running at 2400 rpm to 2700 rpm for rapid chain of impulses.

107. In jet propulsion of ships, when the inlet orifices are at right angles to the direction of motion of the ships, the efficiency of propulsion η is

A. $\frac{2u^2}{V+u}$ B. $\frac{2Vu}{(V+u)^2}$

C. $\frac{2u}{(V+u)^2}$ D. $\frac{2Vu}{V+2u}$

where:

V = Absolute velocity of the issuing jet

U = Velocity of the moving ship

Ans. B

Sol. In jet propulsion of ships, when the inlet orifices are at right angles to the direction of motion of the ships,

Then efficiency of propulsion $\eta = \frac{2Vu}{(V+u)^2}$

108. 0.8 kg of air flows through a compressor under steady state conditions. The properties of air at entry are: pressure 1 bar, velocity 10 m/s, specific volume 0.95m^3/kg and internal energy 30 kJ/kg. The corresponding values at exit are 8 bar, 6 m/s, 0.2 m^3/kg and 124 kJ/kg. Neglecting change in potential energy, the power input will be

A. 117 kW B. 127 kW

C. 137 kW D. 147 kW

Ans. B

Sol. Inlet

P_1 = 1 bar = 100 kPa

V_1 = 10 m/s

v_1 = 0.95 m^3/kg

u_1 = 30 kJ/kg

m'_a = 0.8 kg

Exit

P_2 = 8 bar = 800 kPa

V_2 = 6 m/s

v_2 = 0.2 m^3/kg

u_2 = 124 kJ/kg

By SFEE,

$$m'_a\left[h_1 + \frac{V_1^2}{2000}\right] + \cancel{Q}^0 = m'_a\left[h_2 + \frac{V_2^2}{2000}\right] + P$$

$$m'_a\left[u_1 + p_1v_1 + \frac{V_1^2}{2000}\right] = m'_a\left[u_2 + p_2v_2 + \frac{V_2^2}{2000}\right] + P$$

$$0.8\left[30 + (100 \times 0.95) + \frac{[10]^2}{2000}\right]$$

$$= 0.8\left[129 + (800 \times 0.2) + \frac{(6)^2}{2000}\right] + P$$

100.04 = 227.2144 + P

$$\boxed{P = -127.174\ \text{kW}}$$

Negative sign shows that it is power input.

109. In a power plant, the efficiency of the electric generator, turbine, boiler, cycle and the overall plant are 0.97, 0.95, 0.92, 0.92, 0.42 and 0.33 respectively. In the generated electricity, the auxiliaries will consume nearly

A. 7.3% B. 6.5%
C. 5.7% D. 4.9%

Ans. A

Sol. $\eta_{overall} = \eta_{boiler} \times \eta_{cycle} \times \eta_{gen} \times \eta_{aux} \times \eta_{turbine}$

$0.33 = 0.92 \times 0.42 \times 0.95 \times 0.97 \times \eta_{aux}$

η_{aux} = 0.926

Percentage of Power consumed by auxiliaries = 1 − η_{aux} = 1-0.926 = 7.32%

110. The higher power requirements for compression in a steam power plant working on Carnot vapour cycle

A. Increases the plant efficiency as well as work ratio

B. Reduces the plant efficiency as well as work ratio

C. Does not affect the plant efficiency as well as work ratio

D. Increases the plant efficiency and reduces work ratio

Ans. B

Sol. Plant efficiency

$$\eta = \frac{w_{net}}{Q_S} = \left(\frac{w_T - w_C}{Q_S}\right) \quad .... (1)$$

w_C = Compressor work

as $w_C \uparrow \Rightarrow \eta \downarrow$

Work Ratio,

$$r_w = \frac{w_{net}}{w_T} = \frac{w_T - w_C}{w_T}$$

as $w_C \uparrow \Rightarrow r_w \downarrow$

Hence, as $w_C \uparrow$ Both efficiency and work ratio decrease.

111. For the same compression ratio, the Brayton cycle efficiency is

A. Same as the Diesel cycle efficiency

B. Equal to the Otto cycle efficiency

C. More than the Diesel cycle efficiency

D. Less than the Otto cycle efficiency

Ans. B

Sol. For same compression ratio, Brayton cycle efficiency is same as that of Otto cycle.

112. An economizer in a steam generator performs the function of preheating the

A. Combustion air

B. Feed water

C. Input fuel

D. Combustion air as well as input fuel

Ans. B

Sol. Economizer in a stream generator performs the function of preheating the feed water.

113. Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar and 27°C. The pressure ratio in the cycle is 6. If the relation between the turbine work W_T and compressor work W_C is $W_T = 3W_C$ and $\gamma = 1.4$, the cycle efficiency will be nearly

A. 40% B. 50%

C. 60% D. 70%

Ans. A

Sol. Efficiency, $\eta = 1 - \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}} = 1 - \left(\frac{1}{6}\right)^{\frac{1.4-1}{1.4}} = 40\%$

114. A fluidized bed combustion system having an output of 35 MW at 80% efficiency when using a coal of heating value 26 MJ/kg with a Sulphur content of 3.6% requires a particular limestone to be fed to it at a calcium-sulphur molar ratio of 3.0 so as to limit emissions of SO_2 adequately. The limestone used contains 85% $CaCO_3$. The required flow rate of limestone will be

A. 2405 kg/h B. 2805 kg/h

C. 3205 kg/h D. 3605 kg/h

Ans. A

Sol. Given,

$$\eta = 0.8 = \frac{\text{Power output}}{\text{Heat input}}$$

$$\text{Heat input} = \frac{\text{Power output}}{0.8} = \frac{35\times10^6}{0.8}$$

Since, heat input = $m_f \times c_v$

$$= \frac{35\times10^6}{0.8}$$

$$\text{Mass of fuel } (m_f) = \frac{35\times10^6}{0.8\times26\times10^6}$$

$$\boxed{m_f = 1.682 \text{ kg/sec}}$$

Now, this fuel contains 3.6% if sulphur

So, mass of sulphur = 0.036 × 1.682

= 0.06057 kg/sec

$$\text{Moles of sulphur} = \frac{\text{Mass}}{\text{Molecular mass}}$$

$$= \frac{0.06057}{32} = 0.001893$$

Since, $\frac{\text{Calcium}}{\text{Sulphur}}$ molar ratio = 3

Moles of $CaCO_3$

= 3 × moles of sulphur

= 5.67×10^{-3} K moles/sec

= 20.44 K moles/hr

Mass of $CaCO_3$

= Molecular mass × Number of moles $CaCO_3$

= 100 × 20.44 kg/hr = 2044 kg/hr

Since, limestone contains 85% $CaCO_3$

Actual mass of limestone

$$= \frac{2044}{0.85} = 2405 \text{ kg/hr}$$

115. In Orsat apparatus, when the percentage of carbon dioxide, oxygen and carbon monoxide are known, the remaining gas is assumed to be

A. Hydrogen
B. Sulphur dioxide
C. Nitrogen
D. Air

Ans. C

Sol. In Orsat apparatus, when the percentage of carbon dioxide, oxygen and carbon monoxide are known, the remaining gas is assumed to be Nitrogen.

116. The partial vacuum created by the fan in the furnace and flues, draws the product of the combustion from the main flue and allows them to pass up to the chimney. Such a draught is called

A. Balanced draught

B. Forced draught

C. Induced draught

D. Artificial draught

Ans. C

Sol. Induced draught fans are placed at outlet of the boiler system and exhaust all gaseous combustion products or flue gases from the boiler by creating a partial vacuum within the furnace.

117. Which of the following are applied (used) ways of compounding steam turbines?

1. Pressure compounding

2. Temperature compounding

3. Velocity compounding

A. 1, 2 and 3

B. 1 and 2 only

C. 2 and 3 only

D. 1 and 3 only

Ans. D

Sol. Compounding of steam turbines is done in two ways:

(1) velocity compounding

(2) Pressure compounding

118. A steam ejector which removes air and other non-condensable gases from the condenser is known as

A. Wet air pump
B. Dry air pump
C. Centrifugal pump
D. Circulating pump

Ans. A

Sol. A steam ejector which removes air and other non-condensable gases from the condenser is known as wet air pump.119. In a heat exchanger, 50 kg of water is heated per minute from 50°C to 110°C by hot gases which enter the heat exchanger at 250°C. The value of C_p for water is 4.186 kJ/kg.K and for air is 1 kJ/kg.K. If the flow rate of gases is 100 kg/min, the net change of enthalpy of air will be nearly

A. 17.6 MJ/min
B. 15.0 MJ/min
C. 12.6 MJ/min
D. 10.0 MJ/min

Ans. C

Sol. Enthalpy change of air = enthalpy change of the water

$$\Delta H = mC_p\Delta T$$

$$\Delta H = 50 \times 4.18 \times (110 - 50) = 12.6 MJ/min$$

120. The phenomenon that enables cooling towers to cool water to a temperature below the dry bulb temperature of air is termed as

A. Chemical dehumidification

B. Adiabatic evaporative cooling

C. Cooling and dehumidification

D. Sensible cooling

Ans. B

Sol. The phenomenon that enables cooling towers to cool water to a temperature below the dry bulb temperature of air is termed as adiabatic evaporative cooling.

121. The angle through which the Earth must turn to bring the meridian of a point directly in line with the Sun's rays is called

A. Altitude angle

B. Hour angle

C. Solar azimuth angle

D. Zenith angle

Ans. B

Sol. The angle through which earth must turn to bring meridian of a point directly in sun rays is called hour angle.

122. In which type of collector is solar radiation focused into the absorber form the top, rather than from the bottom?

A. Fresnel lens B. Paraboloidal

C. Concentrating D. Compound parabolic

Ans. D

Sol. In compound parabolic concentrator, solar radiation is focused into absorber form the bottom.

123. A flat plate collector is 150 cm wide and 180 cm high and is oriented such that it is perpendicular to the sun rays. Its active are is 90% of the panel size. If it is in a location that receives solar insolation of 1000 W/m^2 peak, the peak power delivered to the area of the collector will be

A. 1.263 kW B. 2.43 kW

C. 4.46 kW D. 6.26 kW

Ans. B

Sol. Given: area of the flat plate collector, A = 1.5 $\times$ 1.8 = 2.7 m^2

Active area of plate = 0.9 $\times$ 2.7 = 2.43 m^2

solar insolation = 1000 W/ m^2

power delivered, P = solar insolation $\times$ active area = 2.43 $\times$ 1000 = 2.43 kW

124. A surface having high absorptance for short-wave radiation (less than 2.5 μm) and a low emittance of long-wave radiation (more than 2.5 μm), is called

A. Absorber B. Emitter
C. Selective D. Black

Ans. C

Sol. A surface having high absorptance for short wave radiation (less than 2.5 μm) and a low emittance of long-wave radiation (more than 2.5 μm), is called selective surface.

125. in a solar tower power system, each mirror is mounted on a system called

A. Regenerator B. Linear Fresnel
C. Dish D. Heliostat

Ans. D

Sol. In a solar tower system, each mirror is mounted on a system called heliostats. Heliostats are arranged of flat, movable mirrors to focus sun rays upon a collector tower.

126. The ratio of PV cell's actual maximum power output to its theoretical power output is called

A. Quantum factor

B. Fill factor

C. Quantum efficiency

D. PV factor

Ans. B

Sol. Fill factor is ratio of actual maximum power to theoretical power output of a PV cell.

127. With respect to the wind turbine blades, TSR means

A. Tip Swift Ratio

B. Tip Sharp Ratio

C. Tip Speed Ratio

D. Tip Swing Ratio

Ans. C

Sol. In case of wind turbines,

Tip speed ratio (TSR) = Tangential speed / wind speed

128. For a wind turbine 10 m long running at 20 rpm is 12.9 kmph wind, the TSR will be nearly

A. 3.6 B. 5.8

C. 7.6 D. 9.8

Ans. B

Sol. air speed $= 12.9 \times \frac{5}{18}$ = 3.583 m/s

$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 20}{60}$, R = 10m

$\text{TSR} \rightarrow \text{tip speed ratio} = \frac{\text{Tip speed of blade}}{\text{wind speed}}$

$\text{Tip speed ratio} = \frac{\omega R}{3.583} = \frac{2 \times \pi \times 20 \times 10}{60 \times 3.583}$

= 5.85

129. Which one of the following is an enclosure or housing for the generator, gear box and any other parts of the wind turbine that are on the top of the tower?

A. Turbine blade B. Nacelle

C. Turbine head D. Gear box

Ans. B

Sol. Nacelle is an encloser or housing for generator, gearbox and drive train, brake assembly on a wind turbine.

130. The force required for producing tides in the ocean is

A. 70% due to Moon and 30% due to Sun

B. 30% due to Moon and 70% due to Sun

C. 45% due to Moon and 55% due to Sun

D. 55% due to Moon and 45% due to Sun

Ans. A

Sol. Force required for producing tides in ocean is 70% due to moon and 30% due to sun.

131. Which of the following are related to the Proton Exchange Membrane Fuel Cell (PEMFC)?

1. Polymer electrolyte
2. Hydrogen fuel and oxygen
3. Pure water and small amount of electricity
4. Nitrogen

A. 1 and 3 only B. 2 and 4 only

C. 1 and 2 only D. 3 and 4 only

Ans. C

Sol. Proton Exchange Membrane Fuel Cell (PEMFC) is related to polymer electrolyte, hydrogen fuel and oxygen.

132. Which of the following are the essential functions of fuel cells?

1. The charging (or electrolyser) function in which the chemical AB is decomposed to A and B.
2. The storage function in which A and B are held apart.
3. The charge function in which A and B are charged with the simultaneous generation of electricity.

A. 1 and 3 only B. 2 and 3 only

C. 1 and 2 only D. 1, 2 and 3

Ans. B

Sol. Fuel cells are used for storage function and charge function in which A and B are charged with the simultaneous generation of electricity.

Where chemical AB is decomposed into A and B.

133. The position of centroid can be determined by inspection, if an area has

A. Single axis of symmetry

B. Two axes of symmetry

C. An irregular shape

D. Centre axes of symmetry

Ans. B

Sol. The position of centroid can be determined by inspection if an area has two axes of symmetry.

134. Which of the following statements of D'Alembert's Principle are correct?

1. The net external force F actually acting on the body and the inertia force F_1 together keep the body in a state of fictitious equilibrium.

2. The equation of motion may be written as F + (–ma) = 0 and the fictitious force (–ma) is called an inertia force.

3. It tends to give solution of a static problem an appearance akin to that of a dynamic problem.

A. 1 and 3 only

B. 1 and 2 only

C. 2 and 3 only

D. 1, 2 and 3

Ans. B

Sol. option (3) is wrong.

Because D-Alembert's principle tends to give solution of a Dynamic problem an appearance akin to that of a static problem.

135. The linear relationship between stress and strain for a bar in simple tension or compression is expressed with standard notations by the equaiton

A. $\sigma = E\varepsilon$ B. $\sigma = E\nu$

C. $\sigma = G\nu$ D. $\sigma = G\varepsilon$

Ans. A

Sol. By Hook's law,

Stress (σ) ∝ strain (ϵ)

E = Youngs Modulus of Elasticity ⇒ $\boxed{\sigma = \epsilon E}$;

136. A punch is used for making holes in steel plates with thickness 8 mm. If the punch diameter is 20 mm and force required for creating a hole is 110 kN, the average shear stress in the plate will be nearly

A. 139 MPa B. 219 MPa

C. 336 MPa D. 416 MPa

Ans. B

Sol. t = mm, d = 20 mm,

$f = 110 \times 10^3$ N

Let,

s = Average shear stress in plate

∴ F × s × (πdt)

$(110 \times 10^3) = s \times (\pi \times 20 \times 8)$

$\boxed{s = 218.8 \text{ MPa} \cong 219 \text{ MPa}}$....(b)

137. A rod of length 2 m and diameter 50 mm is elongated by 5 mm when an axial force of 400 kN is applied. The modulus of elasticity of the material of the rod will be nearly

A. 66 GPa B. 72 GPa

C. 82 GPa D. 96 GPa

Ans. C

Sol. l = 2 m,

d = 5 mm = 0.05 m

δl = Elongation = 5 mm = 0.005 m

P = force = 400 kN = 400 × 10^3 N

$$\delta l = \frac{Pl}{AE} \Rightarrow E = \frac{Pl}{A\delta l}$$

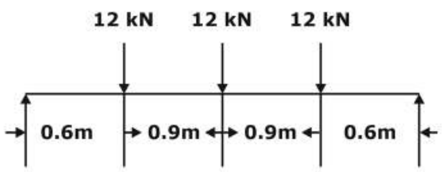
$$\therefore\ E = \frac{P \times l}{\frac{\pi d^2}{4} \times \delta l} = \frac{(4 \times 10^5) \times 2}{\frac{\pi}{4}(0.05)^2 \times 0.05}$$

E = 81.487 × 10^9 Pa

= 81.487 GPa

≅ 82 GPa

138. A beam of span 3 m and width 90 mm is loaded as shown in the figure. If the allowable bending stress is 12 MPa the minimum depth required for the beam will be



A. 218 mm
B. 246 mm
C. 318 mm
D. 346 mm

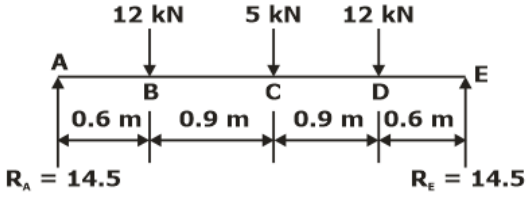
Ans. B

Sol. $R_A + R_S$ = 12 + 5 + 12

= 29 kN ...(i)

Taking moment about A

(R_E × 3) = (2 × 0.6) + (5 × 1.5) + (12 × 2.4)



$\boxed{R_E = 14.5\ \text{kN}}$

∴ (i) ⇒ $\boxed{R_A = 14.5\ \text{kN}}$

Bending moments

M_A = 0

M_B = R_A × 0.6 = 14.5 × 0.6

= 8.7 kNm

M_C = (14.5 × 1.5) – (12 × 0.9)

= 10.95 kN → Maximum B.M.

M_B = (R_E × 0.6) = 14.5 × 0.6

= 8.7 kNm

M_E = 0

∴ M = M_C = 10.95 kN-m

By B.M. equation

as σ = Bending stress $= \frac{6m}{bd^2}$

$$\therefore\ \boxed{\sigma_{max} = \frac{6M}{b(d_{min})^2}}\ ...(2)$$

[d_{min} = minimum depth]

σ_{max}= 12 MPa,

M = (10.95 × 10^6) N-mm

b = 90 mm

$$\therefore\ (2) \Rightarrow 12 = \frac{16 \times 10.95 \times 10^6}{90 \times (d_{min})^2}$$

$\boxed{d_{min} = 246.64\ \text{mm}}$ ...(b)

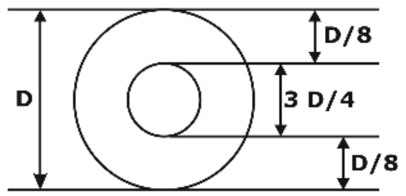
139. A vertical hollow aluminium tube 2.5 m high fixed at the lower end, must support a lateral load 12 kN at its upper end. If the wall thickness is $\frac{1}{8}$th of the outer diameter and the allowable bending stress is 50 MPa, the inner diameter will be nearly

A. 186 mm B. 176 mm

C. 166 mm D. 156 mm

Ans. D

Sol.



$$\frac{\sigma_b}{y} = \frac{M}{I}$$

$$\frac{50}{\frac{D}{2}} = \frac{12\times10^3\times2.5\times10^3}{\frac{\pi}{64}\left[D^4-\left(\frac{3D}{4}\right)^4\right]}$$

$$100 = \frac{64\times12\times10^6\times2.5}{\tau D^3\left[1-\left(\frac{3}{4}\right)^4\right]}$$

$$\text{inner dia} = \frac{3D}{4} = 155.64\text{ mm.}$$

140. A wooden beam AB supporting two concentrated loads P has a rectangular cross-section of width = 100 mm and height = 150 mm. The distance from each end of the beam to the nearest load is 0.5 m. If the allowable stress in bending is 11 MPa and the beam weight is negligible, the maximum permissible load will be nearly

A. 5.8 kN B. 6.6 kN

C. 7.4 kN D. 8.2 kN

Ans. D

Sol. For

$$\sigma_{max.} = \frac{M_{max.}}{Z}$$

$$= \frac{0.5P}{\left(\frac{bd^2}{6}\right)}$$

$$d = \frac{3P}{bd^2}$$

$$P = \sigma_{max.}\left(\frac{bd^2}{3}\right)$$

$$= \frac{11\times10^6\times0.1\times0.15^2}{3}$$

P = 8.250 KN

141. Which of the following statements regarding thin and thick cylinders, subjects to internal pressure only,. Is/are correct?

1. A cylinder is considered thin when the ratio of its inner diameter to the wall thickness is less than 15.

2. In thick cylinders, tangential stress has highest magnitude at the inner surface of the cylinder and gradually decreases towards the outer surface.

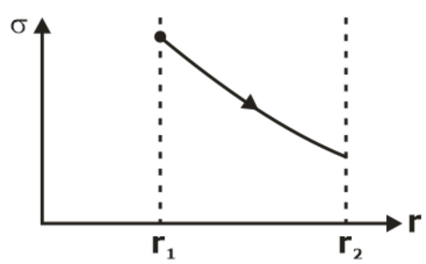
A. 1 only B. 2 only
C. Both 1 and 2 D. Neither 1 nor 2

Ans. B

Sol. • a cylinder is considered thin,

$$\text{if}\left(\frac{D}{t}\right) \geq 20$$

• for thick cylinders variation of tangential stress with radius (r_1) and outer radius (r_2) is as below:



So, only option (2) is correct.

142. A cylindrical storage tank has an inner diameter of 600 mm and a wall thickness of 18 mm. The transverse and longitudinal strains induced are 255 × 10^{-6} mm/mm and 60 × 10^{-6} mm/mm, and if G is 77 GPa, the gauge pressure inside the tank will be

A. 2.4 MPa

B. 2.8 MPa

C. 3.2 MPa

D. 3.6 MPa

Ans. D

Sol. D = 600

t = 18 mm

t_1 = 255 × 10^{-6},

t_2 = 60 × 10^{-6}

G = 77 GPa = 77 × 10^3 MPa

t_1 = transverse & train

$$= \frac{pD}{4tE}(2-u) \quad ...(1)$$

t_2 = longitudinal & train

$$= \frac{pD}{4tE}(1-2u) \quad ...(2)$$

$$\frac{t_1}{t_2} = \left(\frac{2-u}{1-2u}\right) = \frac{255\times10^{-6}}{60\times10^{6}} = 4.25$$

⇒ 2 – u = 4.25 – 8.50 u

7.50u = 2.25

$\boxed{u = 0.3}$

E = 2G(1 + u)

= 2 × 77 × 10^3(1 + 0.3)

= (200.2 × 10^3) MPa

$$\therefore \ (1) \Rightarrow 255\times10^{-6} = \frac{p\times600}{4\times18\times200.2\times10^3}[2-0.3]$$

$\boxed{p = 3.6\ MPa}$

143. A compressed air spherical tank having inner diameter of 450 mm and a wall thickness of 7 mm is formed by welding. If the allowable shear stress is 40 MPa, the maximum permissible air pressure in the tank will be nearly

A. 3 MPa

B. 5 MPa

C. 7 MPa

D. 9 MPa

Ans. B

Sol. D = 450 mm, t = 7 mm, s_{max} = 40 MPa

For spherical tank

$$s_{max} = \frac{pD}{8t}$$

$$\Rightarrow p = \frac{8t}{D}\times s_{max} = \frac{8\times7}{450}\times40$$

$\boxed{p = 4.978\ \text{MPa} \cong 5\ \text{MPa}}$

144. A solid bar of circular cross-section having a diameter of 40 mm and length of 1.3 m is subjected to torque of 340 N.m. If the shear modulus of elasticity is 80 GPa, the angle of twist between the ends will be

A. 1.26° B. 1.32°

C. 1.38° D. 1.44°

Ans. A

Sol. d = 40 mm,

l = 1.3 m = 1300 mm

T = torque=340 Nm

G = 80 GPa = 80 × 10^9 Pa

Angle of twist,

$$\theta = \frac{Tl}{GJ} = \frac{32Tl}{\pi G d^4} = \frac{32 \times 340 \times 1.3}{\pi \times (80 \times 10^9) \times (0.04)^4}$$

= 0.02198 Radian

$$= \frac{0.02198 \times 180}{\pi} = \boxed{1.26^\circ}$$

145. Which one of the following statements regarding screw dislocation is correct?

A. It lies parallel to its Burger vector.

B. It moves in the direction parallel to its Burgers vector.

C. It initially requires very less force to move.

D. It moves very fast as compared to edge dislocation.

Ans. A

Sol. screw dislocation lies parallel to its Burgers vector

146. The percentage of pearlite in a slowly cooled melt of 0.5% carbon steel is

A. 48.5%

B. 52.5%

C. 58.5%

D. 62.5%

Ans. D

Sol. By level rule:

$$\text{wt\% of pearlite}, m_{p=} = \frac{0.5 - 0.008}{0.8 - 0.008} \times 100 = 62.5\%$$

147. In the study of phase diagrams, the rule which helps to calculate the relative proportions of liquid and solid material present in the mixture at any given temperature is known as

A. Hume -Rothery rule

B. Lever rule

C. Gibb's phase rule

D. Empirical rule

Ans. B

Sol. Lever Rule is used to calculate the Relative proportions of liquid and solid material present in the mixture at any given temperature.

148. The phenomenon that artificially increases the dielectric constant of plastics containing fillers is known as

A. Gamma polarization

B. Interfacial polarization

C. Post-forming drawing

D. Reinforcement drawing

Ans. B

Sol. The phenomenon that artificially increases the dielectric constant of plastics containing fillers is known as Interfacial polarization.

149. The addition of alloying elements nickel to cast iron will primarily improve

A. Wear resistance

B. Toughness

C. Carbide formation

D. Machinability

Ans. B

Sol. Nickel impress toughness when added to cast iron.

150. A unidirectional fibre-epoxy composite contains 65% by volume fibre and 35% epoxy resin, If the relative density of the fibre is 1.48 and of the resin is 1.2, the percentage weight of fibre will be nearly

A. 70%

B. 75%

C. 80%

D. 85%

Ans. A

Sol.

	Fibre	Resin
Volume:	$V_f = 0.65$ V	$V_R = 0.35V$;
matrix density:	$f_F = 1.48$	$f_R = 1.2$;

V = Total volume

Percentage weight of fibre

$$= \frac{(f_F \times V_F)}{f_F V_F + f_R \cdot V_R}$$

$$= \frac{(1.48 \times 0.65\ V)}{(1.48 \times 0.65\ V) + (0.35\ V \times 1.2)}$$

= 0.696 = 69.6% ≅ 70%

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