

# ESE 2018

## Paper-2

Mechanical Engineering

► Questions & Solutions



**MECHANICAL-ENGINEERING-ESE-2018**

1. A 150 mm diameter shaft rotates at 1500 rpm within a 200 mm long journal bearing with 150.5 mm internal diameter. The uniform annular space between the shaft and the bearing is filled with oil of dynamic viscosity 0.8 poise. The shear stress on the shaft will be A. 1.77 kN/m<sup>2</sup> B. 2.77 kN/m<sup>2</sup> C. 3.77 kN/m<sup>2</sup> D. 4.77 kN/m<sup>2</sup>

Ans. C

Sol. According to Newton's laws of viscosity

$$\tau = \mu \frac{v}{h} = \mu \frac{v}{h}$$

$$\mu = 0.8 \text{ poise} = 0.08 \text{ Pa-sec}$$

$$v = \frac{\pi DN}{60} = \pi(0.15) \times \frac{1500}{60}$$

$$= 11.781 \text{ m/sec}^2$$

$$h = D_b - D_s$$

(D<sub>b</sub>-Bearing diameter, D<sub>s</sub>-Shaft Diameter).

$$h = \text{Radial clearance} = \frac{D_b - D_s}{2}$$

$$= 0.25 \text{ mm}$$

$$= 0.25 \times 10^{-3} \text{ m}$$

$$\tau = 3769.92 \text{ N/m}^2 = 3.77 \text{ kW/m}^2$$

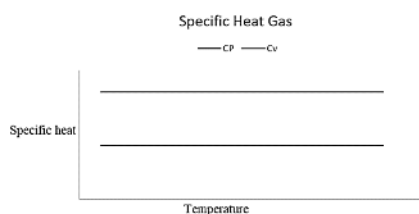
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2. Which one of the following substances has constant specific heat at all pressures and temperatures?

- A. Mono-atomic gas B. Di-atomic gas  
C. Tri-atomic gas D. Poly-atomic gas

Ans. A

Sol. Specific heat gas is the heat required to increase the temperature by 1 degree Celsius. It is generally function of temperature due to intermolecular forces.



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3. The shear stress  $\tau_0$  for steady, fully developed flow inside a uniform horizontal pipe with coefficient of friction  $f$ , density  $\rho$  and velocity  $v$ , is given by

- A.  $\frac{\rho V^2}{2f}$  B.  $\frac{f \rho^2 V}{2}$   
C.  $\frac{\rho^2 V}{2f}$  D.  $\frac{\rho V^2}{2f}$

Ans. A

Sol. According to Von karman Momentum Integral equation,

shear stress

$$= \frac{1}{2} \times \text{density} \times \text{velocity}^2 \times \text{coefficient of friction}$$

$$\tau_o = \frac{1}{2} \rho v^2 f$$

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4. The total energy of each particle at various places in the case of a perfect incompressible fluid flowing in a continuous stream

- A. keeps on increasing  
B. keeps on decreasing  
C. remains constant  
D. may increase or decrease

Ans. B

Sol. Some energy consumed by friction. Hence, keep decreasing.

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5. The normal stresses within an isotropic Newtonian fluid are related to

1. Pressure  
2. Viscosity of fluid  
3. Velocity gradient

Which of the above are correct?

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

Ans. D

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6. Which one of the following regimes of boiling curve can be considered as reverse of condensation?

- A. Free convection boiling regime
- B. Nucleate boiling regime
- C. Transition boiling regime
- D. Film boiling regime

Ans. B

Sol. In condensation bubbles are formed from the steam. Opposite to condensation bubbles are formed in the droplet and starts evaporating.

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7. The service pump in a water supply system has to maintain a net static head lift of 5 m at the tank to which it delivers freely through a 4 km long pipe, wherein all minor losses can be neglected. The diameter of the pipe is 0.2 m and its friction factor  $f = 0.01$ . The pumped water is discharged at 2 m/s. The absolute pressure differential developed by the pump is nearly (taking atmospheric pressure as 10.3 m of water)

- A. 4.5 bar
- B. 5.5 bar
- C. 45 bar
- D. 55 bar

Ans. A

$$\text{Sol. } h_f = \frac{fLv^2}{2gD} = \frac{0.01 \times 4000 \times 2^2}{2 \times 9.81 \times 0.2} = 40.77 \text{ m}$$

$$\text{Static head of pump} = 5 \text{ m}$$

$$\begin{aligned} \text{Total head of pump required} &= 40.77 + 5 \\ &= 45.77 \text{ m} = 4.5 \text{ bar} \text{ Ans} \end{aligned}$$

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8. A wall surface of 200 mm thickness has an outside temperature of 50°C and inside temperature of 25°C with thermal conductivity of 0.51 W/mK. The heat transfer through this wall will be

- A. 63.75 W/m<sup>2</sup>
- B. 65.75 W/m<sup>2</sup>

C. 70.25 W/m<sup>2</sup>

D. 73.25 W/m<sup>2</sup>

Ans. A

Sol.

$$\frac{Q}{A} = k \frac{\partial T}{\partial x} = \frac{0.51 \times 25}{0.200}$$

$$\frac{Q}{A} = 63.75 \text{ W/m}^2$$

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9. The necessary and sufficient condition for bodies in floatation to be in stable equilibrium is that the centre of gravity is located below the

- A. metacentre
- B. centre of buoyancy
- C. epicentre
- D. centroid

Ans. A

Sol. Stable: Position of metacenter is above than center of gravity.

Unstable: Position of metacenter is below than center of gravity.

Unstable: Position of metacenter coincides center of gravity.

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10. When the valve of an evacuated bottle is opened, the atmospheric air rushes into it.

If the atmospheric pressure is 101.325 kPa and 0.6 m<sup>3</sup> of air enters into the bottle, then the work done by the air will be

- A. 80.8 kJ
- B. 70.8 kJ
- C. 60.8 kJ
- D. 50.8 kJ

Ans. C

$$\text{Sol. } W = \int Pdv = 101.325 \times 0.6 = 60.8 \text{ kJ} \text{ Ans}$$

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**11.** A thermodynamic cycle is composed of four processes. The heat added and the work done in each process are as follows:

Process	Heat transfer (J)	Work done (J)
1-2	0	50 (by the gas)
2-3	50 (from the gas)	0
3-4	0	20 (on the gas)
4-1	80 (to the gas)	0

The thermal efficiency of the cycle is

- A. 20.3%                      B. 37.5%  
C. 40.3%                      D. 62.5%

Ans. B

Sol.  $\eta = 1 - \frac{Q_{rej}}{Q_{add}}$   
 $= 1 - \frac{50}{80} = \frac{30}{80} = 37.5\%$

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**12.** A steel tank placed in hot environment contains 5 kg of air at 4 atm at 30°C. A portion of the air is released till the pressure becomes 2 atm. Later, the temperature of the air in the tank is found to be 150°C. The quantity of air allowed to escape is

- A. 4.72 kg                      B. 4.12 kg  
C. 3.71 kg                      D. 3.21 kg

Ans. D

Sol. Applying gas law.

$PV = mRT$

At condition 1.

$4 \times V = 5 \times R \times (273 + 30) \dots\dots\dots 1$

$2 \times V = m \times R \times (273 + 150) \dots\dots\dots 2$

From equation 1 and 2

$m = \left[ \frac{5 \times 303 \times 2}{423 \times 4} \right] = 1.79$

Therefore, the quantity of air escaped =  $5 - 1.79 = 3.21$  Ans.

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**13.** Consider the following statements:

- Entropy is related to the first law of thermodynamics.
- The internal energy of an ideal gas is a function of temperature and pressure.
- The zeroth law of thermodynamics is the basis for measurement of temperature. Which of the above statements are correct?

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

Ans. (D)

Sol. Entropy is related to the second law of thermodynamics

The internal energy of an ideal gas is a function of temperature only.

Hence, only 3<sup>rd</sup> statement is correct.

As per UPSC, The correct option is (C)

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**14.** A heat reservoir is maintained at 927°C. If the ambient temperature is 27°C, the availability of heat from the reservoir is limited to

- A. 57%                                      B. 66%  
C. 75%                                      D. 88%

Ans. C

Sol.  $\eta = 1 - \frac{300}{1200} = 75\%$

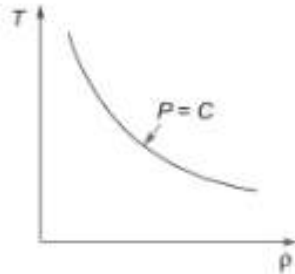
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**15.** The ordinate and abscissa of the diagram to depict the isobaric processes of an ideal gas as a hyperbola are, respectively

- A. temperature and entropy

- B. internal energy and volume
- C. temperature and density
- D. enthalpy and entropy

Ans. C



$$P = \rho RT$$

$$\rho T = \text{Const.}$$

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- 16.** Consider the following statements:
1. The entropy of a pure crystalline substance at absolute zero temperature is zero.
  2. The efficiency of a reversible heat engine is independent of the nature of the working substance and depends only on the temperature of the reservoirs between which it operates.
  3. Carnot's theorem states that of all heat engines operating between a given constant temperature source and a given constant temperature sink, none has a higher efficiency than a reversible engine

Which of the above statement 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 absolute entropy.

$$S = k_B \ln(\Omega)$$

Where, S - Entropy of the system,  
 $k_B$  - Boltzmann's constant,  $\Omega$  Number of microstates.

At absolute zero there is only 1 microstate possible for pure crystalline.

Hence, the entropy of a pure crystalline substance at absolute zero temperature is zero.

$$2. \eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

3. Carnot's theorem states:

All heat engines between two heat reservoirs are less efficient than a Carnot heat engine operating between the same reservoirs.

Hence, all the given statements are correct.

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- 17.** An engine works on the basis of Carnot cycle operating between temperatures of 800 K and 400 K. If the heat supplied is 100 kW, the output is
- A. 50 kW
  - B. 60 kW
  - C. 70 kW
  - D. 80 Kw

Ans. A

$$\text{Sol. } \eta = 1 - \frac{400}{800} = \frac{\text{output}}{100}$$

Engine power output = 50 kW

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- 18.** The coefficient of performance of a heat pump working on reversed Carnot cycle is 6. If this machine works as a refrigerator with work input of 10 kW, the refrigerating effect will be
- A. 35 kW
  - B. 40 kW
  - C. 45 kW
  - D. 50 kW

Ans. D

$$\text{Sol. } \text{COP}_{\text{HP}} = 1 + \text{COP}_{\text{R}}$$

$$\text{COP}_{\text{R}} = 5 = \frac{\text{RE}}{10}$$

RE = 50 kW

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- 19.** Which of the following devices complies with the Clausius statement of the second law of thermodynamics?
- A. Closed-cycle gas turbine
  - B. Internal combustion engine

- C. Steam power plant
- D. Domestic refrigerator

Ans. D

Sol. The Clausius Statement: It is impossible to construct a device which operates on a cycle and produces no other effect than the transfer of heat from a cooler body to a hotter body.

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- 20.** A reversible Carnot engine operates between 27°C and 1527°C, and produces 400 kW of net power. The change of entropy of the working fluid during the heat addition process is
- A. 0.222 kW/K
  - B. 0.266 kW/K
  - C. 0.288 kW/K
  - D. 0.299 kW/K

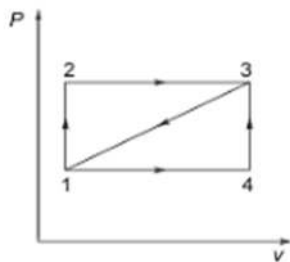
Ans. B

$$\text{Sol. } \eta = 1 - \frac{300}{1800} = 0.833 = \frac{400}{Q_s}$$

$$\Delta S = \frac{480}{1800} = 0.266 \text{ kW/K}$$

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- 21.** A system absorbs 100 kJ as heat and does 60 kJ work along the path 1-2-3. The same system does 20 kJ work along the path 1-4-3. The heat absorbed during the path 1-4-3 is



- A. - 140 kJ
- B. - 80 kJ
- C. 80 kJ
- D. 60 kJ

Ans. D

Sol. Applying 1<sup>st</sup> law of thermodynamics along path: 1-2-3.

$$\delta Q = dU + \delta W$$

$$100 = dU + 60$$

$$dU = 40 \text{ kJ}$$

Area of triangle 123 is 40 KJ.

The area of triangle 143 is same as 123, Hence internal energy for path 143 is 40 KJ.

Now, Applying 1<sup>st</sup> law of thermodynamics along path: 1-4-3.

$$\delta Q = dU + \delta W$$

$$= 20 + 40 = 60 \text{ kJ Ans}$$

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- 22.** Two reversible engines are connected in series between a heat source and a sink. The efficiencies of these engines are 60% and 50%, respectively. If these two engines are replaced by a single reversible engine, the efficiency of this engine will be

- A. 60%
- B. 70%
- C. 80%
- D. 90%

Ans. C

$$\text{Sol. } \eta_{CC}^1 = 1 - \frac{T_{Sink}^1}{T_{Source}^1} = 60 \dots \dots \dots 1$$

$$\eta_{CC}^2 = 1 - \frac{T_{Sink}^2}{T_{Source}^2} = 50 \dots \dots \dots 2$$

Multiplying equ 1 and 2.

$$\left(1 - \frac{T_{Sink}^1}{T_{Source}^1}\right) \times \left(1 - \frac{T_{Sink}^2}{T_{Source}^2}\right) = 60 \times 50$$

As the above engine is in series, therefore,

$$T_{Sink}^1 = T_{Source}^2$$

$$\left(1 - \frac{T_{Sink}^2}{T_{Source}^2} - \frac{T_{Sink}^1}{T_{Source}^1} + \frac{T_{Sink}^2}{T_{Source}^1}\right) = 60 \times 50$$

$$\left(1 - \frac{T_{Sink}^2}{T_{Source}^1}\right) = 1 - \frac{T_{Sink}^2}{T_{Source}^2} + 1 - \frac{T_{Sink}^1}{T_{Source}^1}$$

$$-60 \times 50$$

$$\left(1 - \frac{T_{Sink}^2}{T_{Source}^1}\right) = 1 - \frac{T_{Sink}^2}{T_{Source}^2} + 1 - \frac{T_{Sink}^1}{T_{Source}^1}$$

$$-60 \times 50$$

$$\eta_{CC} = \eta_{CC}^1 + \eta_{CC}^2 - \eta_{CC}^1 \times \eta_{CC}^2$$

$$\eta_{CC} = 60 + 50 - 60 \times 50 = 80\% \text{ Ans}$$

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- 23.** Consider the following statements for the air-standard efficiency of Diesel cycle:

1. For the same compression ratio, the efficiency decreases with increasing cutoff ratios.
  2. For the same compression ratio and same heat input, Diesel cycle is more efficient than Otto cycle.
  3. For constant maximum pressure and constant heat input, Diesel cycle is more efficient than Otto cycle. Which of the above statements are correct?
- A. 1, 2 and 3                      B. 1 and 2 only  
C. 1 and 3 only                    D. 2 and 3 only

Ans. C

Sol. Statement 1 and 3 are correct only

$$\eta_d = 1 - \left(\frac{1}{r}\right)^{\gamma-1} \times \frac{(\rho^\gamma - 1)}{\gamma(\rho - 1)}$$

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- 24.** In case of a thin cylindrical shell, subjected to an internal fluid pressure, the volumetric strain is equal to
- A. circumferential strain plus longitudinal strain
  - B. circumferential strain plus twice the longitudinal strain
  - C. twice the circumferential strain plus longitudinal strain
  - D. twice the circumferential strain plus twice the longitudinal strain

Ans. C

Sol. 
$$\epsilon_v = \frac{\delta V}{V} = \frac{\delta L}{L} + 2\left(\frac{\delta D}{D}\right)$$

$$\epsilon_v = \frac{\delta V}{V} = \epsilon_{long} + 2\epsilon_{hoop}$$

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- 25.** The refractory lining of a furnace has a thickness of 200 mm. The average thermal conductivity of the refractory material is 0.04 W/mK. The heat loss is estimated to be 180 kJ/hr/m<sup>2</sup>. The temperature difference across the lining will be
- A. 280°C                              B. 250°C

- C. 240°C                              D. 220°C

Ans. B

Sol. 
$$Q = K \frac{dt}{dx}$$

$$dt = \frac{(180 \times 1000) \times \frac{200}{1000}}{3600 \times 0.04} = 250 \text{ Ans}$$

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- 26.** In forced convection, the surface heat transfer coefficient from a heated flat plate is a function of
- A. Re and Gr                              B. Pr and Gr  
C. Re and Pr                              D. Re, Gr and Pr

Where Re is Reynolds number, Pr is Prandtl number and Gr is Grashof number.

Ans. C

Sol. Nusselt no. in case of forced convection is a function of Reynolds no. and Prandtl no.

$$Nu = f(Re, Pr)$$

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- 27.** It is desired to increase the heat dissipation rate from the surface of an electronic device of spherical shape of 5 mm radius exposed to convection with  $h = 10 \text{ W/m}^2\text{K}$  by encasing it in a spherical sheath of conductivity 0.04 W/mK. For maximum heat flow, the critical diameter of the sheath shall be
- A. 20 mm                              B. 18 mm  
C. 16 mm                              D. 12 mm

Ans. C

Sol. Critical radius of insulation for sphere,

$$R_{sphere} = \frac{2k}{h} = \frac{2 \times 0.04}{10} \times 1000 \text{ mm} = 8 \text{ mm}$$

$$\text{Critical diameter} = 2 \times \text{Critical radius} = 2 \times 8 = 16 \text{ mm Ans.}$$

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- 28.** If the intake air temperature of an IC engine increases, its efficiency will
- A. remain same  
B. decrease



- C. increase
- D. remain unpredictable

Ans. D

Sol. Efficiency S.I. engine Decreases

Efficiency C.I. engine Increases

But as per UPSC → B

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**29.** In a counter flow heat exchanger, hot gases enter the system at 200°C and leave at 80°C. The temperature of the outside air entering the unit is 35°C. Its temperature at the exit is 90°C. The heat exchanger has an effectiveness of

- A. 0.35
- B. 0.34
- C. 0.33
- D. 0.32

Ans. D

Sol.  $T_{hi} = 200$

$T_{he} = 80$

$T_{ci} = 35$

$T_{ce} = 90$

$$\epsilon = \frac{Q}{Q_{max}} = \frac{T_{hi} - T_{he}}{T_{hi} - T_{ci}}$$

$$\epsilon = \frac{200 - 80}{200 - 35} = 0.73 \text{ Ans}$$

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**30.** If one cylinder of a diesel engine receives more fuel than the others, it is a serious condition for that cylinder and can be checked by

1. judging the seizure of the piston
2. checking incomplete combustion in that cylinder
3. checking cylinder exhaust temperature with a pyrometer

Which of the above is/are correct?

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

Ans. D

Sol. Diesel engine consume more fuel, if engine piston gets seizure or incomplete combustion of fuel. To know the exact reason, check the piston of cylinder and exhaust temperature. Hence all the given statements are correct.

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**31.** Consider the following statements with reference to combustion and performance in a four-stroke petrol engine:

1. The auto-ignition temperature of petrol as a fuel is higher than that of diesel oil as a fuel.
2. The highest compression ratio of petrol engines is constrained by the possibility of detonation.
3. A petrol engine is basically less suitable for supercharging than a diesel engine. Which of the above statements are correct?

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

Ans. D

Sol. 1. The auto-ignition temperature is the minimum temperature at which fuel gets ignites in normal atmosphere.

Fuel Name	Auto-ignition Temperature	Flash Point Temperature
Petrol	256 °C	52 °C
Diesel	280 °C	-43 °C

Due to lower flash point temperature, petrol catches the fire easily.

2. The highest compression ratio of petrol engines is constrained by the possibility of detonation.



3. Supercharge increases the temperature of the inlet air due to compressor and it causes the detonation in the petrol engine.

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**32.** In a flooded evaporator refrigerator, an accumulator at the suction side of the compressor is provided to

- A. collect the vapours
- B. detect any liquids in the vapour
- C. retain the refrigeration effect as originally working
- D. collect the liquid refrigerant and preclude its reversion to the compressor

Ans. D

Sol. Liquid ref. may damage the valve by entering through the compressor.

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**33.** A four-stroke single-cylinder SI engine of 6 cm diameter and 10 cm stroke running at 4000 rpm develops power at a mean effective pressure of 10 bar. The power developed by the engine is

- A. 9.42 kW
- B. 5.54 kW
- C. 4.92 kW
- D. 2.94 kW

Ans. A

$$\text{Sol. } V_s = \frac{\pi}{4} d^2 \times L \times k \times \frac{N}{60 \times 2}$$

$$B.P. = P_{bm} \times V_s = 10V_s = 9.424 \text{ kW Ans}$$

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**34.** Which of the following actions will help to reduce the black smoke emission of a diesel engine?

1. Run at lower load, i.e., derating
2. Have regular maintenance of the diesel engine, particularly of injection system
3. Use diesel oil of higher cetane number Select the correct answer using the code given below.

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

C. 2 and 3 only

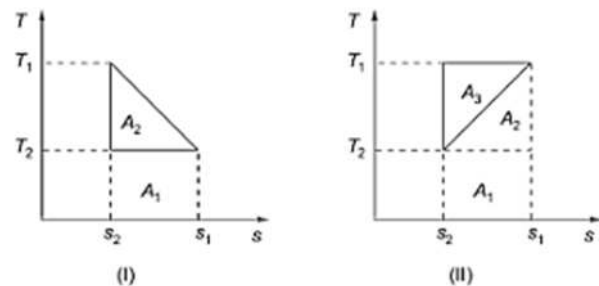
D. 1, 2 and 3

Ans. C

Sol. Incomplete combustion of fuel produces of black smoke. Injection system should be maintained to insure the combustion of injection fuel. Higher cetane number fuel have better ignition quality. Hence, by maintaining injection system with higher cetane number fuel reduce the black smoke.

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**35.** What is the ratio of the efficiencies  $\left(\frac{\eta_I}{\eta_{II}}\right)$  for the two cycles as shown in the T-s diagrams?



- A.  $\frac{2T_2}{T_1 + T_2}$
- B.  $\frac{T_1 + T_2}{2T_2}$
- C.  $\frac{2T_1}{T_1 + T_2}$
- D.  $\frac{2T_1}{T_1 + T_2}$

Ans. D

$$\text{Sol. } \eta_I = \frac{\frac{1}{2}(T_1 - T_2)(s_1 - s_2)}{\frac{1}{2}(T_1 - T_2)(s_1 - s_2)}$$

$$\eta_{II} = \frac{\frac{1}{2}(T_1 - T_2)(s_1 - s_2)}{T_1(s_1 - s_2)}$$

$$\frac{\eta_I}{\eta_{II}} = \frac{T_1(s_1 - s_2)}{\frac{1}{2}(T_1 + T_2)(s_1 - s_2)} = \frac{2T_1}{(T_1 + T_2)}$$

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**36.** A four-stroke engine having a brake power of 105 kW is supplied with fuel at the rate of 4.4 kg/min for 10 minutes. The brake specific fuel consumption of the engine is

- A. 0.18 kg/kW-hr
- B. 0.25 kg/kW-hr
- C. 0.36 kg/kW-hr
- D. 0.42 kg/kW-hr

Ans. D

Sol.  $BSFC = \frac{m_f}{B.P.} = 0.419 \text{ kg/kW-hr}$  Ans

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**37.** Considering the following statements:

1. Recycling exhaust gases by partial mixing with the intake gases increases the emission of oxides of nitrogen from the engine.
2. The effect of increase in altitude of operation on the carburetor is to enrich the entire port-throttle operation.
3. When the carburetor throttle is suddenly opened, the air-fuel mixture may lean out temporarily resulting in engine stall.
4. Use of multi-venturi system makes airstream when the fuel is introduced at the main venturi throat. Which of the above statements are correct?

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

Ans. C

- Sol. 1. Recycling exhaust gases by partial mixing with the intake gases decreases the emission of oxides of nitrogen from the engine.
2. The effect of increase in altitude of operation on the carburetor is to enrich the entire port-throttle operation.
3. When the carburetor throttle is suddenly opened, the air-fuel mixture may lean out temporarily resulting in engine stall.
4. Multiple venturi results the better formation of fuel and air mixture at very low speed causing steady & smooth operation at very low as well as very high speeds

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**38.** In IC engine

1. the ideal air capacity of a two-stroke engine is the mass of air required to concurrently fill the total cylinder volume at inlet temperature and exhaust pressure.

2. with increase in air-fuel ratio beyond the value for maximum power, there is a fall in power developed and this fall is more with higher values of air-fuel ratio

3. the volumetric efficiency of the engine depends on the design of intake and exhaust manifold Which of the above 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. Definition of air capacity of IC Engine.

2. Higher air-fuel ratio is known as lean mixture. As air-fuel ratio increase, the power increases up to the stoichiometric mixture and beyond the stoichiometric mixture power decreases.

$$\eta_{vol} = \frac{VOLUME_{Actual}}{VOLUME_{Theoretical}} = \frac{\frac{MASS_{Actual}}{DENSITY_{Actual}}}{VOLUME_{Theoretical}} = \frac{MASS_{Actual}}{DENSITY_{Actual} \times VOLUME_{Theoretical}}$$

In the above expression  $MASS_{Actual}$  depends on the intake and exhaust manifold of the engine.

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**39.** Consider the following statements:

1. Heat pumps and air conditioners have the same mechanical components.
2. The same system can be used as heat pump in winter and as air conditioner in summer.

3. The capacity and efficiency of a heat pump fall significantly at high temperature. 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. Heat pumps and air conditioners have same mechanical component, its name define the purpose of use if it is used for heating known as heat pump and if it is used for cooling known as air conditioning.

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**40.** The following are the results of a Morse test conducted on a four-cylinder, four-stroke petrol engine at a common constant speed in all cases:

The brake power of the engine when all the cylinders are firing is 80 kW. The brake power of the engine when each cylinder is cut-off in turn is 55 kW, 55.5 kW, 54.5 kW and 55 kW, respectively.

The mechanical efficiency of the engine when all the cylinders are firing will be

- A. 90%                                      B. 85%  
C. 80%                                      D. 75%

Ans. C

Sol.  $B.P_{All\ cylinder\ working} = 80\ kW$

$$I.P_{1st\ cylinder\ working} = 80 - 55\ kW$$

$$I.P_{2nd\ cylinder\ working} = 80 - 55.5\ kW$$

$$I.P_{3rd\ cylinder\ working} = 80 - 54.5\ kW$$

$$I.P_{4th\ cylinder\ working} = 80 - 55\ kW$$

$$\eta_m = \frac{B.P}{I.P} = 80\% \text{ Ans}$$

Search Tag: ESE 2018

**41.** An ideal refrigerator working on a reversed Rankine cycle has a capacity of 3 tons. The COP of the unit is found to be 6. The capacity of the

motor required to run the unit is (take  $1\ T = 210\ kJ/min$ )

- A. 1.85 kW  
B. 1.75 kW  
C. 1.65 kW  
D. 1.5 kW

Ans. B

$$\text{Sol. } Q_L = 3 \times \left(\frac{210}{60}\right) \text{ kW}$$

$$COP = \frac{Q_L}{W_{in}} = \frac{10.5}{W_{in}} = 6$$

$$W_{in} = 1.75\ kW \text{ Ans}$$

Search Tag: ESE 2018

**42.** A flywheel weighs  $\frac{981}{\pi}$  kgf and has a radius of gyration of 100 cm. It is given a spin of 100 rpm about its horizontal axis. The whole assembly is rotating about a vertical axis at 6 rad/s. The gyroscopic couple experienced will be

- A. 2000 kgf-m                              B. 1962 kgf-m  
C. 200 kgf-m                                D. 196 kgf-m

Ans. A

$$\text{Sol. } Gyroscopic\ Couple = I\omega\omega_p$$

$$= \frac{981}{\pi} \times 2\pi \frac{100}{60} \times 6$$

$$= 19620 \cong 2000\ kgf - m \text{ Ans}$$

Search Tag: ESE 2018

**43.** A cold storage has capacity for food preservation at a temperature of  $-3^\circ\text{C}$  when the outside temperature is  $27^\circ\text{C}$ . The minimum power required to operate with a cooling load of 90 kW is

- A. 20 kW  
B. 15 kW  
C. 10 kW  
D. 5 kW

Ans. C

Sol.  $COP = \frac{T_L}{T_H - T_L} = \frac{DE}{W_{in}}$   
 $= \frac{T_L}{T_H - T_L} = \frac{Q_L}{W_{in}}$   
 $= \frac{270}{300 - 270} = \frac{90}{W_{in}}$

$W_{in} = 10 \text{ KW}$  Ans

Search Tag: ESE 2018

- 44.** In a vapour absorption refrigerator, the temperatures of evaporator and ambient air are 10°C and 30°C, respectively. For obtaining COP of 2 for this system, the temperature of the generator is to be nearly
- A. 90°C                                      B. 85°C  
 C. 80°C                                      D. 75°C

Ans. C

Sol.  $Ambient \ temp = 30^\circ C = 303 \text{ K}$

$Evaporator \ temp = 10^\circ C = 283 \text{ K}$

$cop \ of \ system = \eta_{gen} \times COP_{Eva} = 2$

$\left(1 - \frac{303}{T_G}\right) \left(\frac{283}{303 - 283}\right) = 2$

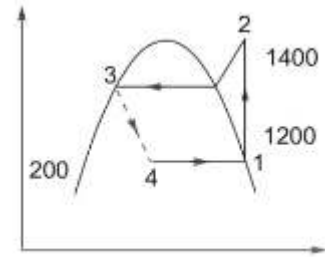
$T_G = 353 \text{ K} = 79.8^\circ C \approx 80^\circ C$  Ans

Search Tag: ESE 2018

- 45.** The following data refer to a vapour compression refrigerator:
- Enthalpy at compressor inlet = 1200 kJ/kg  
 Enthalpy at compressor outlet = 1400 kJ/kg  
 Enthalpy at condenser outlet = 200 kJ/kg  
 The COP of the refrigerator is
- A. 7  
 B. 6  
 C. 5  
 D. 4

Ans. C

Sol.



As from the vapor compressor cycle

$COP = \frac{h_1 - h_4}{h_2 - h_1}$

$COP = \frac{1200 - 200}{1400 - 1200} = 5$  Ans

Search Tag: ESE 2018

- 46.** The compressor of an ammonia refrigerating machine has a volumetric efficiency of 85% and swept volume of 0.28 m<sup>3</sup>/min. Ammonia having a dry specific volume of 0.25 m<sup>3</sup>/kg enters the compressor with a dryness fraction of 0.7. The mass flow rate of ammonia through the machine is
- A. 1.28 kg/min                              B. 1.36 kg/min  
 C. 1.42 kg/min                              D. 1.54 kg/min

Ans. B

Sol.  $Volumetric \ Efficiency = \frac{Vol_{Actual}}{Vol_{Swept}}$

$\frac{Vol_{Actual}}{0.28} = 85$

$Vol_A = 0.28 \times 0.85 = 0.238 = m^3/min$

Now net specific volume,

$V_1 = V_f + x(V_g - V_f)$

$V_1 = x(V_g) \qquad V_f \ll V_{fg}$

$\therefore \dot{m}V_1 = 0.238$

$\dot{m} = \frac{0.238}{0.7 \times 0.25} = 1.36 \text{ kg/min}$  Ans

Search Tag: ESE 2018

- 47.** Air is drawn in a compressor at the rate of 0.8 kg/s at a pressure of 1 bar and temperature of 20°C, and is delivered at a pressure of 10 bar and temperature of 90°C. This air delivery is through an exit valve of area 2 x 10<sup>-3</sup> m<sup>2</sup>. If R is 287 kJ/kgK, the exit velocity of the air is

- A. 41.7 m/s
- B. 35.8 m/s
- C. 29.7 m/s
- D. 27.3 m/s

Ans. A

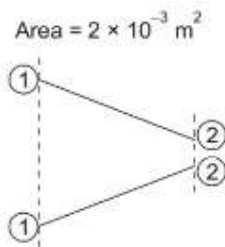
Sol. Inlet properties of gas.

$$\dot{m} = 0.8 \frac{kg}{s}, \quad P_1 = 1 \text{ bar},$$

$$T_1 = (273 + 20) K$$

Outlet properties of gas.

$$P_2 = 10 \text{ bar}, \quad T_2 = (273 + 90) K$$



$$\dot{m} = \rho_2 A_2 V_2$$

$$0.8 = \frac{P_2}{RT_2} \times 2 \times 10^{-3} \times V_2$$

$$0.8 = \frac{10 \times 10}{0.287 \times 363} \times 2 \times 10^{-3} \times V_2$$

$$V_2 = 41.67 \text{ m/sec Ans}$$

Note: Value of R having typographical error the value should be 0.287 kJ/kgK.

Search Tag: ESE 2018

48. Consider the following statements:

1. The operation of a refrigerator unit at more than one temperature can be accomplished by using different throttling valves and a separate compressor for each temperature range.
2. The refrigerated space must be maintained above the ice point to prevent freezing.
3. In domestic refrigerators, the refrigerant is throttled to a higher pressure in the freezer followed by full expansion in the refrigerated space.

Which of the above statements are correct?

- A. 1 and 2 only
- B. 1 only

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

Ans. (B)

Sol. The refrigerated space may be lower than ice temperature.

In domestic refrigerators, the refrigerant is throttled to a lower pressure in the freezer followed by full expansion in the refrigerated space. Hence, only 1<sup>st</sup> statement is correct.

But as per UPSC, correct answer is (A)

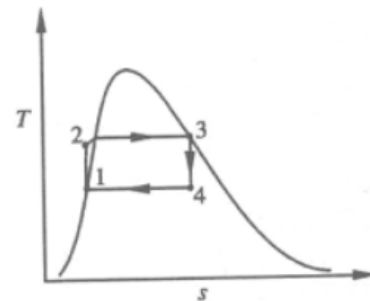
Search Tag: ESE 2018

49. Which one of the following methods is more effective to improve the efficiency of the Rankine cycle used in thermal power plant?

- A. Increasing the condenser temperature
- B. Decreasing the condenser temperature
- C. Decreasing the boiler temperature
- D. Increasing the boiler temperature

Ans. B

Sol.



$$\eta_r = \frac{(h_3 - h_4) - (h_2 - h_1)}{h_3 - h_2}$$

Decreasing a condenser temperature,  $h_3 - h_4$  increases, hence efficiency decrease.

Search Tag: ESE 2018

50. Consider the following statements regarding vapour absorption system in the field of refrigeration:

1. In ammonia-water absorption system, ammonia is the refrigerant.

2. In water-lithium bromide system, water is the refrigerant.

3. Ammonia-water absorption reaction is endothermic.

4. The amount of ammonia absorbed by water is inversely proportional to the temperature of ammonia. Which of the above statements are correct?

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

Ans. C

Sol. Ammonia-water absorption reaction is Exothermic not endothermic.

Search Tag: ESE 2018

**51.** In an air-handling unit, air enters the cooling coil at a temperature of 30°C. The surface temperature of the coil is -10°C. If the bypass factor of the coil is 0.45, then the temperature of the air at the exit will be

- A. 6°C                                  B. 8°C  
C. 10°C                                D. 12°C

Ans. B

Sol.  $BPF_{Coil} = \frac{-T_{coil}}{T_{entry} - T_{coil}}$

$$BPF_{Coil} = \frac{T_{exit} - (-10)}{30 - (-10)}$$

$$\Rightarrow 0.45 = \frac{T_{exit} + 10}{40}$$

$$\Rightarrow T_{exit} = 0.45 \times 40 - 10$$

$$\Rightarrow T_{exit} = 18 - 10 = 8^\circ C \text{ Ans}$$

Search Tag: ESE 2018

**52.** Consider the following statements:

1. The relative humidity of air does not change with temperature as long as specific humidity remains constant.

2. Dew-point temperature is the temperature at which condensation begins when air is cooled at constant volume.

3. Saturated air passing over a water surface does not cause change of air temperature.

4. For saturated air, dry-bulb, wet-bulb and dew-point temperatures are identical. Which of the above statements are correct?

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

Ans. D

Sol. 1. Specific humidity: - Mass of water vapour in a unit mass of moist air at present.

Saturated humidity: - Mass of water vapour in a unit mass of saturated air at present temperature. The saturated humidity of air can increase with increase in temperature.

Relative humidity: - The ratio of amount of water vapor present in the air to the water vapor in air at saturated condition. On the other hand, the ratio of specific humidity to the saturated humidity.

Hence, relative humidity can change with temperature at constant specific humidity.

2. Dew-point temperature is the temperature at which condensation begins when air is cooled at constant Pressure.

Hence, statement 3 and 4 are correct.

Search Tag: ESE 2018

**53.** A cold storage has 23 cm brick wall on the outside and 8 cm plastic foam on the inside. The inside and outside temperatures are -2°C and 22°C, respectively. If the thermal conductivities of brick and foam are 0.98 W/m-K and 0.02 W/m-K, and the inside and outside heat transfer coefficients are 29 W/m<sup>2</sup>-K and 12 W/m<sup>2</sup>-K, respectively, then the rate of heat removal for a (projected) wall area of 90 m<sup>2</sup> will nearly be

- A. 503 W                                B. 497 W

C. 490 W

D. 481 W

Ans. B

Sol. 
$$Q_{re} = \frac{T_{out} - T_{in}}{\frac{1}{h_1} + \frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{1}{h_2}}$$

$$Q_{re} = \frac{22 - (-2)}{\left(\frac{1}{29} + \frac{0.08}{0.02} + \frac{0.23}{0.98} + \frac{1}{12}\right) \times \frac{1}{90}}$$

$Q_{removal} = 496.265 W = 497 W$  Ans

Search Tag: ESE 2018

**54.** Consider the following statements:

1. The distinguishing features of a radial flow reaction turbine are— (i) only a part of the total head of water is converted into velocity head before it reaches the runner and (ii) the flow-through water completely fills all the passages in the runner.
2. Kaplan turbine is essentially a propeller working in reverse, and its blades are so mounted that all the blade angles can be adjusted simultaneously by means of suitable gearing even as the machine is in operation.
3. A draft tube is a pipe of gradually increasing cross-sectional area which must be airtight, and under all conditions of operation, its lower end must be submerged below the level of the discharged water in the tailrace.

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. • In reaction turbine, work is produced by utilizing both kinetic & potential energy of the fluid. Hence, head is partially converted into Kinetic energy (i.e. velocity).  
 • In Kaplan turbine, the orientation of moving angle can also be adjusted.  
 • The draft tube is always immersed in tail race to create negative pressure at tail end. It helps the water to discharge easily.

Search Tag: ESE 2018

- 55.** The specific speed of a turbine is the speed of an imaginary turbine, identical with the given turbine, which
- A. delivers unit discharge under unit speed
  - B. delivers unit discharge under unit head
  - C. develops unit discharge under unit speed
  - D. develops unit power under unit head

Ans. D

Sol. Specific speed of turbine: - Speed of geometrically similar turbine which produce unit power under unit head.

Search Tag: ESE 2018

- 56.** The mechanical efficiency of a centrifugal pump is the ratio of
- A. manometric head to the energy supplied by the impeller per kN of water
  - B. energy supplied to the pump to the energy available at the impeller
  - C. actual work done by the pump to the energy supplied to the pump by the prime mover
  - D. energy available at the impeller to the energy supplied to the pump by the prime mover

Ans. D

Sol. Energy is supplied by motor to the pump shaft, some energy consumed in friction & mechanical isolation. The remaining energy goes to the impeller.

$$\eta_{mech} = \frac{\text{Energy available at Impeller}}{\text{Energy at pump shaft}}$$

Search Tag: ESE 2018

- 57.** Consider the following advantages of rotary pumps compared to reciprocating pumps:
1. Steady discharge which increases with decrease in head
  2. Suitable for handling fluids with suspended solid particles



3. Less bulky than displacement pumps positive

4. Can be started with open delivery with least load Which of the above advantages are correct?

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

Ans. C

Sol. Reciprocating pump gives steady discharge which increases with decrease in head. This type pumps are not suitable for fluid having suspended solid particles. Suspended particles damage the guide vane.

Search Tag: ESE 2018

**58.** According to aerofoil theory, the guide angle of Kaplan turbine blades is defined as the angle between

- A. lift and resultant force  
B. drag and resultant force  
C. lift and tangential force  
D. lift and drag

Ans. A

Sol. According to Aerofoil theory, the guide angle of Kaplan turbine blades is defined as the angle between lift & resultant force.

Search Tag: ESE 2018

**59.** An ideal closed-cycle gas turbine plant is working between the temperatures 927°C and 27°C using air as working fluid. The pressure ratio for maximum output is

- A. 11.3                                  B. 13.3  
C. 15.3                                  D. 17.3

Ans. A

Sol. From Brayton cycle,

$$W_{net} = mC_p \left[ T_3 \left( 1 - \left( \frac{1}{r} \right)^{\frac{\gamma-1}{\gamma}} \right) - T_1 \left( (r_p)^{\frac{\gamma-1}{\gamma}} - 1 \right) \right]$$

For optimum pressure ratio,  $\frac{dw_{net}}{dr_p} = 0$ .

$$(r_p)_{opt} = \frac{T_{max}^{\frac{\gamma}{2(\gamma-1)}}}{T_{min}} = \left( \frac{1200}{300} \right)^{\frac{1.4}{2 \times (1.4-1)}}$$

$$= (r_p)_{opt} = (4) \times 2 \sqrt{2} = 11.31 \text{ Ans}$$

Search Tag: ESE 2018

**60.** The critical speed of a turbine is

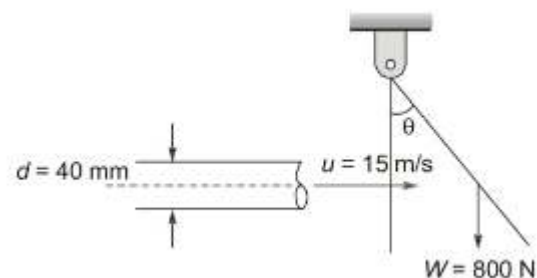
- A. same as the runaway speed  
B. the speed that will lead mechanical failure of the shaft  
C. the speed which equals the natural frequency of the rotor  
D. the speed equal to the synchronous speed of the generator

Ans. C

Sol. The speed of turbine at which it equals to Natural frequency. At this speed, deflection of shaft is maximum & it should not run at that speed.

Search Tag: ESE 2018

**61.** A 40 mm diameter water jet strikes a hinged vertical plate of 800 N weight normally at its surface at its centre of gravity as shown in the figure below:



The angle of deflection is nearly

- A.  $\sin^{-1} 0.353$                       B.  $\sin^{-1} 0.321$   
C.  $\tan^{-1} 0.353$                       D.  $\tan^{-1} 0.321$

Ans. A

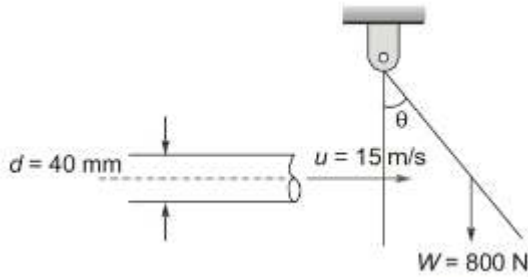
Sol. Weight = 800 N.

Moment (-ve) at hinged =  $W \left( \frac{L}{2} \right) \sin \theta$

Force by liquid =  $\rho AV^2$

Moment (+ve) at hinged =  $\rho AV^2 \cos \theta \times \left( \frac{L}{2 \cos \theta} \right)$

[Note: - liquid jet will deflect the plate hence striking point of jet will be at distance of  $(\frac{L}{2 \cos \theta})$  along the plate]



Taking momentum at hinged point,

$$W \left(\frac{L}{2}\right) \sin \theta = \rho AV^2 \cos \theta \times \left(\frac{L}{2 \cos \theta}\right)$$

$$\theta = \sin^{-1} \left(\frac{\rho AV^2}{W}\right)$$

$$\theta = \frac{1000 \times \left(\frac{\pi}{4} \times 0.04^2\right) \times 15^2}{800}$$

$$\theta = \sin^{-1} (0.353) \text{ Ans}$$

[Note: -Moment due to weight of plate will not change if position of striking jet changes in vertical direction, but jet moment will change.

Hence for general case.  $\sin \theta = \frac{\rho av^2 \left(\frac{x}{2}\right)}{w \cdot \frac{l}{2}}$ .

Search Tag: ESE 2018

**62.** Consider the following statements regarding a Ram Jet:

1. The engine has neither a compressor nor a turbine.
2. It operates at much higher temperature than a gas turbine.
3. It cannot operate statically. It needs to be put in flight by some means at sufficiently high speed before it produces any thrust and propels itself.

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. It uses engine forward motion to compress the air. Therefore, it can not produce thrust at zero speed. Temperature of the inlet air got increases due to high compression.

Search Tag: ESE 2018

**63.** Air enters a turbojet engine at the rate of 40 kg/s with a velocity of 250 m/s relative to an aircraft which is moving at 300 km/hr. Exhaust of the engine has a velocity of 700 m/s relative to the moving aircraft. The thrust developed by the engine is

- A. 24 kN                                      B. 18 kN  
C. 12 kN                                      D. 9 kN

Ans. B

Sol. Thrust = Change of momentum of air

$$Thrust = m(V_E - V_{in})$$

$$Thrust = 40(700 - 250) = 18 \text{ KN Ans}$$

Search Tag: ESE 2018

**64.** The clearance volume in reciprocating air compressor is provided

- A. to reduce the work done per kg of air delivered  
B. to increase the volumetric efficiency the compressor  
C. to accommodate the valves in the head of the compressor  
D. to create turbulence in the air to be delivered

Ans. C

Sol. The cylinder of reciprocating air compressor has inlet and outlet valve. Therefore, clearance volume is provided to accommodate the valve.

Search Tag: ESE 2018

**65.** Consider the following statements regarding Reheat Rankine Steam Cycle:

1. The main purpose of reheat in Rankine cycle is to increase the efficiency of the cycle.

2. In practice, the reheat is generally limited to one point of expansion.

3. Due to reheat, the steam rate (specific steam consumption) is reduced. Which of the above statements are correct?

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

Ans. B

Sol. The main purpose of reheat in Rankine cycle is to avoid excess moisture in steam. It may not increase the efficiency of the Rankine cycle.

Search Tag: ESE 2018

**66.** In solar flat-plate collectors, the absorber plate is painted with selective paints. The selectivity is the ratio of

- A. solar radiation-absorption to thermal infrared radiation-emission
- B. solar radiation-emission to thermal infrared radiation-absorption
- C. solar radiation-reflection to thermal infrared radiation-absorption
- D. solar radiation-absorption to thermal infrared radiation-reflection

Ans. A

Sol. The solar flat-plate collectors absorber are made of combination of two paint to transfer the radiation to the absorber and prevent the radiation to escape.

Search Tag: ESE 2018

**67.** A 13 m long ladder is placed against a smooth vertical wall with its lower end 5 m from the wall. What should be the coefficient of friction between the ladder and the floor so that the ladder remains in equilibrium?

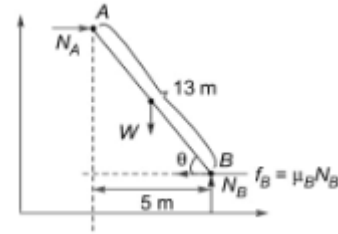
- A. 0.29
- B. 0.25

C. 0.21

D. 0.11

Ans. C

Sol.



Taking moment about point A.

$$\sum M_A = 0$$

$$-\frac{5}{2}W - 12\mu_B N_B + 5N_B = 0$$

$$\mu_B = \frac{\left(-\frac{5}{2}W + 5N_B\right)}{12N_B}$$

$$\mu_B = \frac{5}{12} - \frac{2.5W}{12N_B}$$

$$\sum F_v = 0 \therefore W = N_B$$

$$\mu_B = \frac{5}{12} - \frac{2.5}{12} = 0.21 \text{ Ans}$$

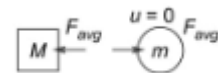
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**68.** A cube strikes a stationary ball exerting an average force of 50 N over a time of 10 ms. The ball has mass of 0.20 kg. Its speed after the impact will be

- A. 3.5 m/s
- B. 2.5 m/s
- C. 1.5 m/s
- D. 0.5 m/s

Ans. B

Sol.



Applying Newton's second law of motion

$$F_{avg} = \frac{mv - mu}{\Delta t}$$

$$50 = \frac{m \times v - 0}{10 \times 10^{-3}} = \frac{0.2 \times v}{10 \times 10^{-3}}$$

$$v = \frac{50 \times 10 \times 10^{-3}}{0.2} = 2.5 \text{ m/s Ans}$$

Search Tag: ESE 2018

**69.** Consider the following statements regarding solid solution of metals:

1. The solubility of metallic solids is primarily limited by size factor.
2. A metal with high valence can dissolve large amount of metal of lower valence.
3. A metal with same lattice crystal structure can form a series of solid solutions.
4. The limit of solid solubility is indicated by a phase boundary called Liquidus. Which of the above statements are correct?

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

Ans. C

Sol. 1. Yes, the solubility depends on the relative size factor and difference between atomic radius should not more than 15%.

2. No, lower valence can dissolve more higher valence metal.

3. Yes, as well as they behave as extensive solubility.

4. No, it's not called "Liquidus" it's called as "Solvus".

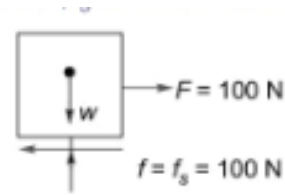
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**70.** A box of weight 1000 N is placed on the ground. The coefficient of friction between the box and the ground is 0.5. When the box is pulled by a 100 N horizontal force, the frictional force developed between the box and the ground at impending motion is

- A. 50 N                      B. 75 N  
C. 100 N                      D. 500 N

Ans. C

Sol.  $w = 1000\text{ N}$ ,  
 $\mu_s = 0.5$ ,       $F = 100\text{ N}$



$$\therefore F_s = \mu_s \cdot N = 0.5 \times 1000 = 500\text{ N}$$

$\therefore F < F_s$ , the applied force is less than frictional force. Hence, the frictional force developed in between box and ground will be equal to applied force.

$$\therefore f = f_s = F = 100\text{ N Ans}$$

Search Tag: ESE 2018

**71.** A state of plane stress consists of a uniaxial tensile stress of magnitude 8 kPa, exerted on vertical surfaces and of unknown shearing stresses. If the largest stress is 10 kPa, then the magnitude of the unknown shear stress will be

- A. 6.47 kPa                      B. 5.47 kPa  
C. 4.47 kPa                      D. 3.47 kPa

Ans. C

Sol. Stress and shear stress acting on the body, and maximum stress is 10 kPa. We know that maximum stress in the body is principle stress.

$$\sigma_1 = 10\text{ kPa}$$

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

$$10 = \frac{8}{2} + \sqrt{\left(\frac{8}{2}\right)^2 + \tau^2}$$

$$6 = \sqrt{4^2 + \tau^2}$$

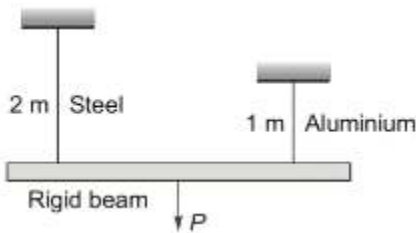
$$36 = 16 + \tau^2 \Rightarrow \tau^2 = 20$$

$$\tau = 4.47\text{ kPa Ans}$$

Search Tag: ESE 2018

**72.** A rigid beam of negligible weight, is supported in a horizontal position by two rods of steel and aluminium, 2 m and 1 m long, having values of cross-sectional areas 100 mm<sup>2</sup> and 200 mm<sup>2</sup>, and Young's modulus of 200 GPa and 100 GPa,

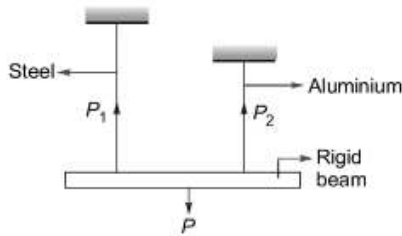
respectively. A load  $P$  is applied as shown in the figure below:



- If the rigid beam is to remain horizontal, then
- A. the force  $P$  must be applied at the centre of the beam
  - B. the force on the steel rod should be twice the force on the aluminium rod
  - C. the force on the aluminium rod should be twice the force on the steel-rod
  - D. the forces on both the rods should be equal

Ans. C

Sol.



The rigid beam will remain in the center if and only if the elongation of both rods remains same.

$$(\delta L)_1 = (\delta L)_2$$

$$\frac{P_1 L_1}{A_1 E_1} = \frac{P_2 L_2}{A_2 E_2}$$

$$\frac{P_1 \times 2000}{100 \times 200 \times 10^3} = \frac{P_2 \times (1000)}{200 \times 100 \times 10^3}$$

$$P_2 = 2P_1 \text{ [i.e. } P_{Al} = 2P_{steel}]$$

Search Tag: ESE 2018

- 73.** A solid shaft is subjected to bending moment of 3.46 kN-m and a torsional moment of 11.5 kN-m. For this case, the equivalent bending moment and twisting moment are
- A. 7.73 kN-m and 12.0 kN-m
  - B. 14.96 kN-m and 12.0 kN-m
  - C. 7.73 kN-m and 8.04 kN-m
  - D. 14.96 kN-m and 8.04 kN-m

Ans. A

Sol.  $M = 3.46 \text{ kN-m}$

$T = 11.5 \text{ kN-m}$



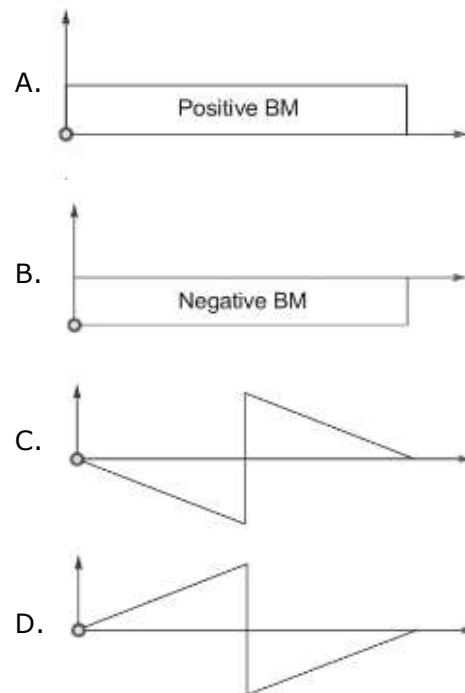
To find the equivalent bending and twisting moment using max principal stress theory [MPST] and Maximum shear stress theory.

$$M_e = \frac{1}{2} [M + \sqrt{M^2 + T^2}] = 7.73 \text{ kN-m}$$

$$T_e = \sqrt{M^2 + T^2} = 12 \text{ kN-m}$$

Search Tag: ESE 2018

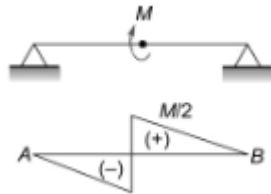
- 74.** Which one of the following is the correct bending moment diagram for a beam which is hinged at the ends and is subjected to a clockwise couple acting at the mid-span?



Ans. C

Sol. From the given clock wise moment, the bending created left side & right side of hinged

point will be hogging type & and sagging type. Hence, left side will be negative moment and right side will be positive moment. Therefore option "C" is correct.



Also,

Moment about point A,  $M_A = 0$

Moment at left side of mid point,

$$M_C = -F_v \left(\frac{L}{2}\right) = \frac{-M}{L} \left(\frac{L}{2}\right) = \frac{-M}{2} \text{ Ans}$$

Search Tag: ESE 2018

- 75.** A steel specimen is heated to 780°C and is then cooled at the slowest possible rate in the furnace. The property imparted to the specimen by this process is
- A. toughness                      B. hardness  
C. softness                         D. tempering

Ans. C

Sol. Softness: Very slow cooling.

Search Tag: ESE 2018

- 76.** Consider the following statements:
1. In case of a thin spherical shell of diameter  $d$  and thickness  $t$ , subjected to internal pressure  $p$ , the principal stresses at any point equal  $\frac{pd}{4t}$
  2. In case of thin cylinders, the hoop stress is determined assuming it to be uniform across the thickness of the cylinder.
  3. In thick cylinders, the hoop stress is not uniform across the thickness but it varies from a maximum value at the inner circumference to a minimum value at the outer circumference.
- 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. In thin cylinder the hoop stress variation in the cylinder is negligible, therefore, it is determined by assume the uniform hoop stress across the thickness of cylinder. But as the thickness of the cylinder is increases the stress variation increases across the thickness and it is not considered uniform across the thickness. The variation of the hoop stress in thick cylinder is form maximum value at the inner circumference to a minimum value at the outer circumference.

Therefore, all statements are correct.

Search Tag: ESE 2018

- 77.** Addition of magnesium to cast iron increase its
- A. hardness  
B. corrosion resistance  
C. creep strength  
D. ductility and strength in tension

Ans. D

Sol. Addition of magnesium to cast iron increase its ductility and strength in tension.

Search Tag: ESE 2018

- 78.** Consider the following statements:
1. The quenching of steel results in an increase in wear resistance, strength and hardness.
  2. By the process of case-hardening, hard wearing resistant surface is produced on mild steel. This is an effective method for low-carbon steels because they cannot be hardened by the process of quenching.
  3. When a metal is mixed with small atoms of non-metallic element in such a manner that invading atoms occupy interstitial positions in the metal lattice, an interstitial alloy results.

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. Quenching: Increase the wear resistance, strength and hardness of steel. Low carbon steel required very high rate of quenching for martensite transformation due to low carbon, and it is impossible to achieve required cooling rate for martensite transformation. Hence, case-hardening is suitable method for low carbon steel.

When a metal is mixed with small atoms of non-metallic element in such a manner that invading atoms occupy interstitial positions in the metal lattice, an interstitial alloy result.

Hence, all statements are correct.

Search Tag: ESE 2018

- 79.** Recrystallization temperature is one at which
- A. crystals first start forming from molten metal when cooled
- B. new spherical crystals first begin to form from the old deformed ones when that strained metal is heated
- C. the allotropic form changes
- D. crystals grow bigger in size

Ans. B

Sol. Recrystallization temperature is one at which new spherical crystals first begin to form from the old deformed ones when that strained metal is heated.

Search Tag: ESE 2018

- 80.** Fe-C alloy containing less than 0.83% carbon is called
- A. high-speed steel
- B. hypo-eutectoid steel
- C. hyper-eutectoid steel
- D. cast iron

Ans. B

Sol. All iron-carbon alloys experience eutectoid transformation. The eutectoid concentration of carbon is 0.83%. Hence, Fe-C alloy containing less than 0.83% carbon is called hypo-eutectoid steel.

Search Tag: ESE 2018

- 81.** Which of the following statements are correct?
- Steel and cast iron are multi-phase alloys.
  - Ferrite is a single-phase interstitial solid solution of carbon in iron.
  - Wrought iron is a highly refined iron with a small amount of slag which gives resistance to progressive corrosion.
  - Stellite contains large amounts of metals like cobalt and tungsten resulting in high hardness.
- Select the correct answer using the code given below.
- A. 1, 2, 3 and 4                      B. 1, 2 and 3 only  
C. 1, 3 and 4 only                      D. 2 and 4 only

Ans. A

Sol. 1. Steel and cast iron are multi-phase alloys.

Alloy	Composition
Cast Iron	Iron, Carbon, Manganese, Silicon
Steel	Iron, Carbon (plus small amounts of other elements)

- Ferrite ( $\alpha$ ) is a single-phase interstitial solid solution of carbon in BCC iron.
- wrought iron have small amount of non-corrosive slag which gives the resistant to progressive corrosion. Addition to that presence of slag produces a structure which diminishes the effect of fatigue caused by shocks and vibrations.
- The Stellite is a group of cobalt-chromium alloys designed for wear resistance. The alloy may contain tungsten with small amount of carbon to offer greater performance for specific application.



Search Tag: ESE 2018

**82.** Which one of the following statements is correct?

- A. Microprocessor is more suitable for general purpose and microcontroller is more suitable for special purpose and custom-built application.
- B. Microprocessor and microcontroller are suitable for general purpose application.
- C. Microprocessor and microcontroller are suitable for special purpose application.
- D. Microprocessor and microcontroller are suitable for special purpose and custom-built application.

Ans. A

Sol. Microcontroller is made for specific purpose, it contains Microprocessor, ROM, RAM, keyboard etc. But Microprocessor is for general purpose.  
Search Tag: ESE 2018

**83.** The unique property of cast iron is its high

- A. malleability
- B. ductility
- C. toughness
- D. damping characteristics

Ans. D

Sol. Properties of cast iron are as follows.

1. Low Tensile Strength
2. Low Melting Point
3. High damping characteristics.
4. High Compressive Strength
5. Resistance to Deformation
6. Resistance to Oxidation

Search Tag: ESE 2018

**84.** Which one of the following pairs of tests has been developed to evaluate the fracture resistance of engineering materials, subjected to dynamic loads or impacts?

- A. Tension impacts and Bending impacts
- B. Tensile test and Brinell hardness test
- C. Vickers hardness test and Tensile test
- D. Scleroscope test and File test

Ans. A

Sol. Tension impacts and Bending impacts test is done for fracture resistance of engineering materials, subjected to dynamic loads.

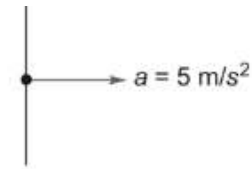
Search Tag: ESE 2018

**85.** The midpoint of a rigid link of a mechanism moves as a translation along a straight line, from rest, with a constant acceleration of  $5 \text{ m/s}^2$ . The distance covered by the said midpoint in 5 s of motion is

- A. 124.2 m
- B. 112.5 m
- C. 96.2 m
- D. 62.5 m

Ans. D

Sol.



Using equation of motion.

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

$$s = 0 + \frac{1}{2} \times 5 \times 5 \times 5$$

$$s = 62.5 \text{ m Ans}$$

Search Tag: ESE 2018

**86.** Consider the following statements:

1. A kinematic chain is the combination of kinematic pairs joined in such a way that the relative motion between them is completely constrained.
2. The degree of freedom of a kinematic pair is given by the number of independent

coordinates required to completely specify the relative movement.

Which of the above statements is/are correct?

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

Ans. C

Sol. The independent coordinates (parameters) define the configuration of a mechanism, and a complete constrain kinematic chain gives the desire motion.

Search Tag: ESE 2018

**87.** The equation of motion for a single degree of freedom system is

$$4\ddot{x} + 9\dot{x} + 16x = 0$$

The critical damping coefficient for the system is

- A.  $4\sqrt{2}$
- B. 4
- C.  $16\sqrt{2}$
- D. 16

Ans. D

Sol. Given equation of motion,

$$4\ddot{x} + (9)\dot{x} + (16)x = 0$$

Hence,  $m = 4$ ,  $C = 9$ , and  $k = 16$ .

Critical damping =  $2m\omega_n$

$$C_c = 2m \sqrt{\frac{k}{m}} = 2\sqrt{mk}$$

$$C_c = 2\sqrt{4 \times 16} = 16 \text{ Ans}$$

Search Tag: ESE 2018

**88.** The mass of a single-degree damped vibrating system is 7.5 kg and it makes 24 free oscillations in 14 s when disturbed from its equilibrium position. The amplitude of vibration reduces to 0.25 of its initial value after five oscillations. Then the logarithmic decrement will be

- A.  $\frac{2}{5} \log_e 6$
- B.  $\frac{1}{5} \log_e 6$
- C.  $\frac{1}{5} \log_e 4$
- D.  $\frac{2}{5} \log_e 6$

Ans. C

Sol. Initial disturbed amplitude =  $x_0$

Amplitude after 5<sup>th</sup> oscillations =  $x_5$

Given,

$$\frac{x_5}{x_0} = 0.25 = \frac{1}{4}$$

$$\therefore \frac{x_0}{x_1} \cdot \frac{x_1}{x_2} \cdot \frac{x_2}{x_3} \cdot \frac{x_3}{x_4} \cdot \frac{x_4}{x_5} = 4$$

And we know that,

$$\frac{x_0}{x_1} = \frac{x_1}{x_2} = \frac{x_2}{x_3} = \frac{x_3}{x_4} = \frac{x_4}{x_5}$$

Applying logarithmic decrement,

$$e^{5\delta} = 4$$

$$5\delta = \ln 4$$

$$\delta = \frac{1}{5} \ln 4 \text{ Ans}$$

Search Tag: ESE 2018

**89.** A 20 kg mass is suspended from a spring which deflects 15 mm under this load. The value of the critical damping coefficient to make the motion aperiodic will be

- A. 1010 N/m/s
- B. 1013 N/m/s
- C. 1018 N/m/s
- D. 1023 N/m/s

Ans. D

Sol.  $m = 20 \text{ kg}$

$$\Delta = 15 \text{ mm} = 0.015 \text{ m}$$

$$W_n = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{9.81}{0.015}}$$

$$C_c = 2mW_n$$

$$C_c = 2 \times 20 \times \sqrt{\frac{9.81}{0.015}}$$

$$C_c = 1023 \text{ N/m/s Ans}$$

Search Tag: ESE 2018

**90.** Consider the following statements:

1. The whirling (critical) speed of a shaft is that rotational speed at which the shaft so runs that the deflection of the shaft from the axis of rotation tends to become infinite
2. Critical speed is equal to the frequency of transverse vibration of a shaft when the shaft carries a point load or a uniformly distributed load or a combination of both such loads.
3. The whirling of a shaft results from causes such as mass unbalance, hysteresis damping in the shaft, gyroscopic forces and fluid friction in the bearing.

Which of the above statements are correct?

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

Ans. A

Sol. The whirling of a shaft results from causes such as point load (self-load) or a uniformly distributed load or a combination of both such loads in the shaft. This load deflects the shaft axis from mounted axis. When shaft starts rotating, deflected axis starts increasing towards outward from mounted axis and it reached to the maximum value at whirling (critical) speed.

Search Tag: ESE 2018

**91.** Consider the following statements:

1. In spur gears, the contact occurs abruptly on a line parallel to the axis, and the disengagement too is abrupt.
2. In helical gears, both loading and unloading are gradual, and therefore, these happen more smoothly and less noisily.
3. When two gears mesh, any arbitrary shape of the tooth can be chosen for the profile of the teeth of any one of the two gears, and the

profile for the other shall be obtained by applying the law of gearing.

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. The profile satisfies the requirement known as conjugate profile. Many tooth shapes are possible that can satisfy the gear law, but only two are in general use: involute profiles and cycloidal profile.

Search Tag: ESE 2018

**92.** The interference between a given pinion tooth and a gear tooth can be avoided by using

1. smaller pressure angle
  2. larger pressure angle
  3. less number of teeth on the gear for a pinion with predefined number of teeth
  4. more number of teeth on the gear for a pinion with predefined number of teeth
- Which of the above are correct?

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

Ans. C

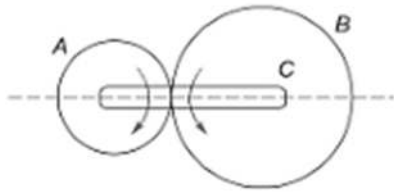
Sol. Larger pressure angle makes smaller base circle. The tooth profile between the actual base circle and smaller base circle also having the involute profile. Because of this involute profile, tooth tip of one gear do not contact with the flank of other gear.

More number of teeth on the gear also prevent the chances of interference.

Search Tag: ESE 2018

**93.** A gear train is as shown in the figure below, in which gears A and B have 20 and 40 teeth,

respectively. If arm C is fixed and gear A rotates at 100 r.p.m., the speed of gear B will be



- A. 90 r.p.m.
- B. 75 r.p.m.
- C. 50 r.p.m.
- D. 20 r.p.m.

Ans. C

Sol. [Observation: As arm is fixed, the given system is a simple gear train and the size of Gear B is twice of Gear A. Hence, speed of Gear B will be half i.e. 50 rpm.]

	Arm C	A (20 teeth)	B (40 teeth)
Arm is fixed	0	+x	$-x \times \frac{20}{40}$
Arm is free	y	y+x	$y - x \times \frac{20}{40}$

Speed of gear A,

$$y + x = 100$$

Speed of arm,

$$N_c = 0 \quad y = 0$$

$$y + x = 100$$

$$x = 100$$

Speed of gear B,

$$N_B = y - \frac{x}{2}$$

$$N_B = 0 - \frac{100}{2} = -50 \text{ Ans}$$

Alternative way:

$$\frac{N_B}{N_A} = \frac{T_A}{T_B} = \frac{20}{40}$$

$$N_B = \frac{100}{2} = 50 \text{ rpm Ans}$$

Search Tag: ESE 2018

94. A single-cylinder reciprocating engine works with a stroke of 320 mm, mass of reciprocating parts as 45 kg and mass of revolving parts as 35 kg at crank radius. If 60% of the reciprocating parts and all the revolving parts are to be balanced, then the balancing mass required at a 300 mm radius is nearly

- A. 33.1 kg
- B. 36.3 kg
- C. 39.5 kg
- D. 42.7 kg

Ans. A

Sol. Crank radius =  $\frac{\text{Stroke}}{2}$

$$r = \frac{320}{2} = 160 \text{ mm} = 0.160 \text{ m}$$

$$m_{\text{Recl}} = 45 \text{ kg}$$

$$m_{\text{Rot}} = 35 \text{ kg}$$

Unbalanced force

$$F_u = m \times \omega^2 \times r \left( \cos \theta + \frac{\cos 2\theta}{n} \right)$$

[Note: form the above equation the unbalanced force is maximum at  $\theta = 0$ ]

$$\text{Mass to be balanced} = 35 + 0.6 \times 45 = 62$$

Now, let  $M_B$  is the required mass and  $B$  is the required radius to balance the given unbalanced mass with the same rotational speed.

$$M_B \times B = 62 \times 160$$

$$\therefore M_B = \frac{62 \times 160}{300} = 33.1 \text{ Ans}$$

Search Tag: ESE 2018

95. Consider the following statements:

1. Gyroscopic effects generate forces and couples which act on the vehicles, and these effects must be taken into account while designing their bearings.
2. Rolling motion of a ship usually occurs because of the difference in buoyancy on the two sides of the ship due to a wave.

Which of the above statements is/are correct?

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

Ans. C

Sol. If a wheel revolves about OX axis and a couple called gyroscopic couple is applied along OY axis, then the body tries to move about OZ axis. This effect is known as gyroscopic effect.

In the vehicle, all wheels have rotation say about OX-Axis, and when it gets turns say about OY axis, the wheel tries to move in OZ axis (perpendicular to OX and OY). These couple applied to the bearings. Hence, these effects must be considered while designing their bearings.

When difference in buoyancy is applied to the ship, higher buoyancy applies more the upward force compared to the lower buoyance, which result the tilting of ship. This tilting direction changes when the higher buoyancy applied in the other direction. This process of tilting is known as rolling motion of shop.

Hence both 1 and 2 are correct.

Search Tag: ESE 2018

- 96.** When two shafts, one of which is hollow, are of the same length and transmit equal torques with equal maximum stress, then they should have equal
- A. polar moments of inertia  
 B. polar moduli  
 C. diameters  
 D. angles of twist

Ans. B

Sol. Torsional equation of shaft

$$\frac{T}{J} = \frac{t}{r} = \frac{G \theta}{L}$$

$$t = \frac{T}{\frac{J}{r}} = \frac{\text{Torque}}{\text{Polar modulus}}$$

Given that Torque and shear stress of for both solid and hollow shafts are equal.

Therefore,  $(Polar Modulus)_{solid}$  is equal to the  $(Polar Modulus)_{Hollow}$

Search Tag: ESE 2018

- 97.** A solid rod of circular cross-section made of brittle material, when subjected to torsion, fails along a plane at 45° to the axis of the rod. Consider the following statements as pertaining thereto:

1. Distortion energy is maximum on this 45° plane.
2. Shear stress is maximum on this 45° plane.
3. Normal stress is maximum on this 45° plane.

Which of the above is/are correct?

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

Ans. C

Sol. Brittle material shaft fails at 45° to the axis along a plane because maximum tensile stress occurs at that location in same direction and it is weak in tension. The failure occurs in the shape of granular helicoidal.

Search Tag: ESE 2018

- 98.** A riveted joint may fail by
1. tearing of the plate at an edge
  2. tearing of the plate across a row of rivets
  3. shearing of rivets

Which of the above 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. A riveted joint may fail by

1. tearing of the plate at an edge
2. tearing of the plate across a row of rivets
3. shearing of rivets
4. Crushing of the plate or rivets

Hence all statements are correct.

Search Tag: ESE 2018

- 99.** An offset provided in radial cam-translating-follower mechanism serves to
- A. decrease the pressure angle during ascent of the follower
  - B. increase the pressure angle during ascent of the follower
  - C. avoid possible obstruction due to some machine parts
  - D. decrease the pressure angle during descent of the follower

Ans. A

Sol. At the time of ascent of follower, the required pressure to push the follower is more. By decreasing the pressure angle, thrust can be reduced. There are many ways to decrease the pressure angle between cam and follower like attaching roller to the follower at contact point, giving curve shape to the follower at the contact point and Providing offset.

Search Tag: ESE 2018

- 100.** In combined parallel and transverse fillet welded joint
- A. the parallel portion will fail due to tension, whereas the transverse portion will fail due to shear
  - B. the transverse portion will fail due to tension, whereas the parallel portion will fail due to shear
  - C. both parallel and transverse portions will fail due to tension
  - D. both parallel and transverse portions will fail due to shear

Ans. D

Sol. In both cases maximum shear stress occurs at  $45^\circ$  angle of plane.

Search Tag: ESE 2018

- 101.** In a journal bearing, the diameter of the journal is 0.15 m, its speed is 900 r.p.m. and the load on the bearing is 40 kN. considering  $\mu = 0.0072$ , the heat generated will be nearly
- A. 1 kW
  - B. 2 kW
  - C. 3 kW
  - D. 4 kW

Ans. B

Sol. Heat generate = work done by frictional force

Work done by bearing =  $(\mu \times W) \times r \omega$

$$(Heat)_{gen} = \mu W \frac{\pi DN}{60}$$

$$(Heat)_{gen} = 0.0072 \times 40 \times \frac{\pi \times 0.15 \times 900}{60}$$

$$(Heat)_{gen} = 2.035 \text{ kW Ans}$$

Search Tag: ESE 2018

- 102.** Which one of the following governors is having a larger displacement of sleeve for a given fractional change of speed?
- A. Stable governor
  - B. Sensitive governor
  - C. Isochronous governor
  - D. Hunting governor

Ans. D

Sol. Hunting governor are too sensitive governor, which changes the fuel supply by larger amount. When speed of engine decreases, the sleeve of governor falls to its lower position quickly. As the sleeve reaches its lower position, delivery of fuel increases. More fuel increases the speed of engine, and governor sleeve goes in upper position to cut the fuel. The process continues, and the sleeve of governor moves from lower position to the upper position and vice versa.

Search Tag: ESE 2018

- 103.** Consider the following statements:

1. HSS tools wear very rapidly, whereas in cemented carbide tools, even though hardness is retained, crater wear can occur due to solid-state diffusion.

2. Cutting tools made of Super-HSS also known as cobalt-based HSS, are made by adding 2% to 15% of cobalt which increases the cutting efficiency at heavier cuts by increasing the hot hardness and wear resistance.

3. Tool failure due to excessive stress can be minimized by providing small or negative rake angles on brittle tool materials, protecting tool tip by providing large side-cutting edge angles, and honing a narrow chamfer along the cutting edge.

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. Wear resistance of carbide is more than HSS tools. In solid state diffusion tool material get diffused and deposited over the workpiece.

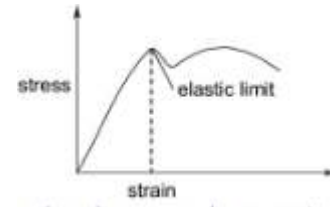
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**104.** The resilience of steel can be found by integrating stress-strain curve up to the

- A. ultimate fracture point  
B. upper yield point  
C. lower yield point  
D. elastic point

Ans. D

Sol. Resilience of a material is the ability to absorb energy by up to elastic limit. Hence, The area under the stress strain curve of steel up to the elastic point is resilience of steel.



Search Tag: ESE 2018

**105.** While turning a 60 mm diameter bar, it was observed that the tangential cutting force was 3000 N and the feed force was 1200 N. If the tool rake angle is  $32^\circ$ , then the coefficient of friction is nearly (may take  $\sin 32^\circ = 0.53$ ,  $\cos 32^\circ = 0.85$  and  $\tan 32^\circ = 0.62$ )

- A. 1.37                                      B. 1.46  
C. 1.57                                      D. 1.68

Ans. A

Sol. Principal cutting-edge angle is  $90^\circ$ .

Tool rake angle is  $32^\circ$

$F_c = 3000 \text{ N}$ ,  $F_t = 1200 \text{ N}$

$$\mu = \frac{F_c \sin \alpha + F_t \sin \alpha}{F_c \sin \alpha - F_t \sin \alpha}$$

$$\mu = \frac{3000 \sin 32 + 1200 \cos 32}{3000 \cos 32 - 1200 \sin 32}$$

$$\therefore \mu = 1.36 \text{ Ans}$$

Search Tag: ESE 2018

**106.** For spot welding of 1 mm thick sheet with a current flow time of 0.2 s, the heat generated is 1000 J. If the effective resistance is  $200 \mu\Omega$

, the current required is

- A. 4000 A                                      B. 5000 A  
C. 6000 A                                      D. 7000 A

Ans. B

Sol. Heat generation due to current  $= I^2 RT$

$$I = \sqrt{\frac{H}{RT}} = \sqrt{\frac{1000}{200 \times 10^{-6} \times 0.2}}$$

$$I = 5000 \text{ A Ans}$$

Search Tag: ESE 2018



- 107.** The maximum possible draft in rolling, which is the difference between initial and final thicknesses of the sheet metal, depends on
- rolling force
  - roll radius
  - roll width
  - yield shear stress of the material

Ans. B

Sol.  $\Delta H = \mu^2 R$

It is obvious that the higher radius will give more draft.

Search Tag: ESE 2018

- 108.** For a strain gauge (gauge factor = 2.1 and resistance =  $50\ \Omega$ ), subjected to a maximum strain of 0.001, the maximum change in resistance is
- $0.084\ \Omega$
  - $0.105\ \Omega$
  - $0.135\ \Omega$
  - $0.156\ \Omega$

Ans. B.

Sol. strain gauge factor = 2.1

Resistance =  $50\ \Omega$

$\epsilon_{\text{maximum}} = 0.001$

$$\text{Gauge factor} = \frac{\Delta R}{R \epsilon}$$

$\Delta R = 0.001 \times 50 \times 2.1 = 0.105\ 13\ \text{Ans}$

Search Tag: ESE 2018

- 109.** Consider the following statements: Dispatching authorizes the start of production operation by
- releasing of material and components from stores to the first process.
  - releasing of material from process to process.
  - issuing of drawing and instruction sheets.
- Which of the above statements are correct?
- 1 and 2 only
  - 1 and 3 only
  - 2 and 3 only
  - 1, 2 and 3

Ans. D

Sol. Dispatching is the execution phase of planning. In this phase, protection activities are set in motion by releasing of orders and instruction. It also authorized the start of production activities by releasing materials, components, tools fixture and instruction sheets.

Search Tag: ESE 2018

- 110.** Which one of the following forecasting models best predicts the turning point?
- Simple exponential smoothing model
  - Brown's quadratic smoothing model
  - Double exponential smoothing model
  - Moving average model (using 5 data points)

Ans. D

Sol. In Moving average method, Past observation are weighted equally (constant weighted), whereas, in the other given forecasting method, different weights are assigned over different historical data, generally in the increase weight. Which make the forecasting more smooth and do not show sudden change in direction or pattern when considering smoothing model.

Search Tag: ESE 2018

- 111.** The material removal rate will be higher in ultrasonic machining process for materials with
- higher ductility
  - higher fracture strain
  - higher toughness
  - lower toughness

Ans. D

Sol. Ultrasonic machining process remove the material by vibration in presence of fine abrasive particles. The hard and brittle materials like GLASS, ceramics carrying low toughness are machined by this process.

Search Tag: ESE 2018

**112.** In queuing theory with multiple servers, the nature of the waiting situation can be studied and analyzed mathematically, if

- A. the complete details of the items in the waiting lines are known
- B. the arrival and waiting times are known and can be grouped to form an appropriate waiting line model
- C. all the variables and constants are known and they may form a linear equation
- D. the laws governing arrivals, service times and the order in which the arriving units are taken into service are all known

Ans. D

Sol. Expected waiting time in system,

$$W_s = \frac{1}{\lambda - \mu}$$

Where,  $\lambda$  – arrival rate,  $\mu$  – service rate

Hence, option D is correct.

Search Tag: ESE 2018

**113.** In any crash program for a project

- A. both direct and indirect costs increase
- B. indirect costs increase and direct costs decrease
- C. direct costs increase and indirect costs decrease
- D. costs are of no criterion

Ans. C

Sol. Crashing is a schedule compression technique used to shorten the project schedule (project completion time). This can be reduced by crashing the following process.

1. Reducing the planning and design cost.
2. Speedup the raw material procurement
3. Increasing the labour

By doing so the cost of planning, design, material procurement and labour cost increase, which is direct cost of project.

Search Tag: ESE 2018

**114.** Tool signature is

- A. a numerical method of identification of the tool
- B. the plan of the tool
- C. the complete specification of the tool
- D. associated with the tool manufacturer

Ans. C

Sol. Tool signature represents the complete specification of tool.

Example ASA tool signatures:

$$ASA (\alpha_b, \alpha_s, \gamma_e, \gamma_s, \psi_e, \psi_s, r_n)$$

Search Tag: ESE 2018

**115.** With reference to a microprocessor, RISC stands for

- A. Redefined Instruction Set Computer
- B. Reduced Instruction Set Computer
- C. Restructured Instruction Set Computer
- D. Regional Instruction Set Computer

Ans. B

Sol. RISC: Reduced Instruction Set Computer

Search Tag: ESE 2018

**116.** An OR logic control in pneumatic systems is possible with the help of

- A. sequence valve
- B. shuttle valve
- C. dual pressure valve
- D. delay valve

Ans. B

Sol. A. Sequence valve is a pilot control valve.

- B. shuttle valve is an OR logic control valve.
- C. dual pressure valve is as AND logic control valve.
- D. Delay valve use to delay the vacuum signal.

Search Tag: ESE 2018

**117.** Which one of the following is not an addressing Mode in 8085?

- A. Immediate                      B. Indirect  
C. Register                         D. Segment

Ans. D

Sol. Addressing modes in 8085 is classified into 5 groups.

1. Direct addressing mode
2. Register addressing
3. Immediate addressing
4. Implied Addressing
5. Immediate addressing

Search Tag: ESE 2018

**118.** Consider the following statements regarding Programming Logic Controller (PLC):

1. It was developed to replace the microprocessor
  2. Wiring between devices and relay contacts are done in its program.
  3. Its I/O interface section connects it to external fields devices.
  4. It requires extensive wiring in the application.
- Which of the above statements are correct?

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

Ans. C

Sol. Programming Logic Controller (PLC) was developed to replace hard-wired relays, timers and sequencers. Later it become very famous in automation controllers. In today world, almost all the motor and machine are integrated with PLC controller.

Search Tag: ESE 2018

**119.** If B is the magnetic flux density at right angle to a plate, I is the current flow through the plate, t is the plate thickness and  $K_H$  is Hall

coefficient, the resultant transverse potential difference V for Hall sensor is given by

- A.  $K_H \frac{BI}{t}$                               B.  $K_H \frac{t}{BI}$   
C.  $K_H \frac{BI}{t}$                               D.  $K_H \frac{I}{Bt}$

Ans. C

Sol. Hall effect voltage =  $K_H \frac{BI}{t}$

Search Tag: ESE 2018

**120.** The specific speed of a hydraulic turbine depends on

- A. speed and power developed  
B. speed and water head  
C. discharge and power developed  
D. speed, head and power developed

Ans. D

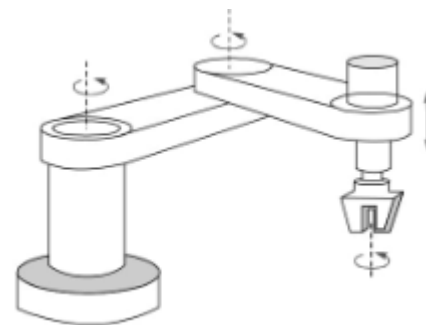
Sol.  $N_s = \frac{N\sqrt{P}}{H^{5/4}}$

Search Tag: ESE 2018

**121.** The degrees of freedom of a SCARA robot are

- A. six                                      B. five  
C. four                                     D. three

Ans. C



SCARA has 3 rotational and 1 translational motion. Hence, total 4 degree of freedom.

Search Tag: ESE 2018

**122.** Which one of the following devices produces incremental motion through equal pulses?

- A. AC servomotor                      B. DC servomotor  
C. Stepper motor                        D. Series motor

Ans. C

Sol. Servomotor motor have inbuilt potentiometer, and it is used to control the angular position by applying fixed voltage to it.

Stepper motor have many magnetic pol built in it. Its incremental motion depends on input pushes.

Search Tag: ESE 2018

**123.** A force of 400 N is required to open a process control valve. What is the area of diaphragm needed for a diaphragm actuator to open the valve with a control gauge pressure of 70 kPa?

- A. 0.0095 m<sup>2</sup>
- B. 0.0086 m<sup>2</sup>
- C. 0.0057 m<sup>2</sup>
- D. 0.0048 m<sup>2</sup>

Ans. C

Sol.  $A = \frac{F}{P} = \frac{400}{70 \times 10^3} = 0.0057 \text{ m}^2$

Search Tag: ESE 2018

**124.** A force of 10 kN is required to move a workpiece. What is the needed working pressure, if the piston diameter is 100 mm?

- A. 1.55 MPa
- B. 1.46 MPa
- C. 1.27 MPa
- D. 1.12 MPa

Ans. C

Sol.  $P = \frac{F}{A} = \frac{10 \times 10^3}{\frac{\pi}{4} \times (0.1)^2}$

$P = 1.27 \times 10^6 \text{ Pa}$

$P = 1.27 \text{ MPa}$

Search Tag: ESE 2018

**125.** If a workpiece is moved by 50 mm in 10 s by a piston of diameter 100 mm, the hydraulic liquid flow rate is nearly

- A. 3.00 x 10<sup>-5</sup> m<sup>3</sup>/s
- B. 3.93 x 10<sup>-5</sup> m<sup>3</sup>/s
- C. 4.74 x 10<sup>-5</sup> m<sup>3</sup>/s
- D. 5.00 x 10<sup>-5</sup> m<sup>3</sup>/s

Ans. B

Sol.  $V = \frac{50 \times 10^{-3}}{10} = 5 \times \frac{10^{-3} \text{ m}}{\text{sec}}$

$Q = AV = \frac{\pi}{4} (0.1)^2 \times 5 \times 10^{-3}$

$Q = 3.93 \times 10^{-5} \text{ m}^3/\text{sec}$

Search Tag: ESE 2018

**126.** Which of the following are the basic building block elements for a mechanical system where forces and straight line displacements are involved without any rotation?

- 1. Spring
- 2. Dashpot
- 3. Mass
- 4. Moment of inertia

Select the correct answer using the code given below:

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

Ans. D

Sol. Moment of Inertia involve the rotational motion.

Search Tag: ESE 2018

**127.** Consider the following statements regarding electromechanical devices:

- 1. A potentiometer has an input of rotation and an output of a potential differences.
- 2. An electric motor has an input of a potential difference and an output of rotation of a shaft.
- 3. A generator has an input of rotation of a shaft and an output of a potential difference.

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. A potentiometer is a variable resistance, whose resistance varies with rotation. A fixed voltage is applied to the potentiometer, as the resistance changes the output voltage changes. It is very useful to measure the angle of rotation. Hence, potentiometer have rotation as a input and voltage as a output.

2. An electric motor has an input of a electrical potential difference and an output of rotation of a shaft.

3. A generator has an input of rotation of a shaft and an output of a potential difference, which is used to generate electricity.

Search Tag: ESE 2018

**128.** The indirect operation of solenoid valve in pneumatic circuit is designed to reduce

1. valve size towards lowering the cost
2. coil size and electrical power consumption
3. response time

Which of the above is/are relevant to the context?

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

Ans. B

Sol. Solenoid valve is a valve which regulate the opening of fluid flow by means of electromagnetic actuation.

In indirect operation of solenoid valve, opening is regulated by taking feedback form the flow line itself and electromagnetic actuation is used for setting the output flow criteria. Hence, the actuation of solenoidal only required when the output criteria change. Therefore, the coil size and power consumption reduce.

Search Tag: ESE 2018

**129.** Consider the following statements:

- 1 Robots take permissible actions only.
2. All actions that are obligatory for robots are actually performed by them subject to ties and conflicts among available actions.
3. All permissible actions can be proved by the robot to be permissible and it can be explained in ordinary English.

Which of the above statements are correct?

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

Ans. D

Sol. All statements are Necessary and Sufficient Conditions for an Ethically Correct Robot. Hence option D is correct answer.

People often got confused by 3<sup>rd</sup> statement.

“All permissible (or obligatory or forbidden) actions can be proved by the robot (and in some cases, associated systems, e.g., oversight systems) to be permissible (or obligatory or forbidden), and all such proofs can be explained in ordinary English”

Search Tag: ESE 2018

**130.** Consider the following statements relating to the term 'Robot Repeatability':

1. It is a statistical term associated with accuracy in the action.
2. It is a measure of the ability of the robot to position the tool tip in the same place repeatedly.
3. It does not describe the error with respect to absolute coordinates.

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. C

Sol. Repeatability is not a statistical term, it means that how accurately the same position can be reached if the motion is repeated many times.

Search Tag: ESE 2018

**131.** Consider the following statements regarding homogeneous coordinate transformation matrix:

1. A homogeneous transformation matrix can be considered to consist of four sub-matrices.
2. The upper left 3 x 3 sub-matrix represents the position vector.
3. The upper right 3 x 1 sub-matrix represents the rotation matrix.
4. The lower left 1 x 3 sub-matrix represents perspective transformation. Which of the above statements are correct?

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

Ans. B.

Sol. Homogeneous transformation matrix

(3 × 3) Rotational Matrix	(3 × 1) Translational Matrix
(1 × 3) Respective Transformation	(1 × 1) Scale Factor

Example of Homogeneous transformation matrix ( $\theta$  degree rotation about Z-Axis with Zero translation).

$$Matrix_{Rot} = \begin{bmatrix} \cos \theta & -\sin \theta & 0 & 0 \\ \sin \theta & \cos \theta & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Search Tag: ESE 2018

Direction: Each of the next nineteen (19) items consists of two statements, one labelled as the 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

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.

**132.** Statement (I): A differential inverted U-tube manometer determines the difference in pressures between two points in a flow section to which it is connected.

Statement (II): The sensitivity of an inclined gauge depends on the angle of inclination.

Ans. B

Sol. Higher pressure point pushes the liquid to the higher than the lower pressure point, and the difference indicate the difference in pressure between these points.

Search Tag: ESE 2018

**133.** Statement (I): In four-bar chain, whenever all four links are used, with each of them forming a turning pair, there will be continuous relative motion between the two links of different lengths.

Statement (II): for a four-bar mechanism, the sum of the shortest and longest link lengths is not greater than the sum of remaining two links.

Ans. C

Sol. For making a four-bar mechanism sum of three link should be greater than longest link. For inversion purpose, the sum of longest and smallest should be less than sum of other two.  
 Search Tag: ESE 2018

**134.** Statement (I): When flow is unsteady, both normal and tangential components of acceleration will occur.

Statement (II): During unsteady flow, in addition to the change of velocity along the path, the velocity will also change with time.

Ans. D

Sol. Normal component can only occur in case of curved stream line. Without a normal component, fluid flow can be unsteady state flow.

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**135.** Statement (I): There exists a positive pressure difference between the inlet and throat of a venturi meter.

Statement (II): The coefficient of discharge of a venturimeter accounts for the non-uniformity of flow at both inlet and throat.

Ans. B

Sol. At the inlet point of venturi, the velocity of the fluid is less than the velocity at throat, which result the more pressure at the entry point and less pressure at the throat point.

The venturi has reducing cross-section area from the entry point to the throat point. As the fluid flow from the entry point to the throat, fluid velocity starts increasing. Hence, at both the point area varies in the flow direction, therefore the flow is non-uniform at both points.

Search Tag: ESE 2018

**136.** Statement (I): The phase of a substance is characterized by its distinct molecular arrangement which is homogeneous throughout and is separated from the others by easily identifiable boundary surfaces.

Statement (II): Phase change is not characterized on molecular structure and/or behaviour of the difference phases.

Ans. C

Sol. The phase of substance is identified as distinct molecular arrangement that is homogeneous & separated from the other by easily identifiable boundary surface.

Molecular structure does not change, when phase of substance got change.

Search Tag: ESE 2018

**137.** Statement (I): Non-viscous flow between two plates held parallel with a very small spacing between them is an example of irrotational flow.

Statement (II): forced vortex implies irrotational flow.

Ans. C

Sol. Natural vortex is irrotational flow.

Search Tag: ESE 2018

**138.** Statement (I): The air-fuel ratio employed in a gas turbine is around 60 : 1.

Statement (II): A lean mixture of 60 : 1 in a gas turbine is mainly used for complete combustion.

Ans. A

Sol. Higher air-fuel ratio indicates the lean mixture. Lower air-fuel ratio increases the air temperature. Gas turbine is set to the maximum allowable temperature to prevent the turbine blade and other equipment from high thermal stress. Hence, lean mixture result the complete combustion at allowable temperature.

Search Tag: ESE 2018

**139.** Statement (I): the condenser in a steam power plant is always filled with a mixture of water, steam and air.

Statement (II): Slightly wet steam enters the condenser wherein the pressure is below the atmospheric conditions, causing some leakage of air through the glands and also the release of some air dissolved in the boiler feedwater.

Ans. A



Sol. Condensers are heat exchanger, which convert steam from its gaseous to its liquid state at lower pressure (lower than the atmospheric pressure). Due to the negative pressure in the condenser the outside air comes inside and form the mixture of steam, water and air.  
Search Tag: ESE 2018

**140.** Statement (I): In a pipeline, the nature of the fluid flow depends entirely on the velocity.  
Statement (II): Reynolds number of the flow depends on the velocity, the diameter of the pipe and the kinematic viscosity of the fluid.

Ans. D

Sol. No! not only on velocity, it is also depends on roughness of surface.  
Search Tag: ESE 2018

**141.** Statement (I): The air-standard efficiency of Brayton cycle depends only on the pressure ratio.  
Statement (II): For the same compression ratio, the air-standard efficiency of Brayton cycle is equal to that of Otto cycle.

Ans. B

Sol. For air,  $(r_p)^{\frac{\gamma-1}{\gamma}} = (r)^{\gamma-1} = \frac{T_1}{T_2}$   
$$\eta_b = 1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}} = 1 - \frac{T_2}{T_1} = \eta_{otto}$$

Search Tag: ESE 2018

**142.** Statement (I): The energy of an isolated system constant.  
Statement (II): The entropy of an isolated system can increase but cannot decrease.

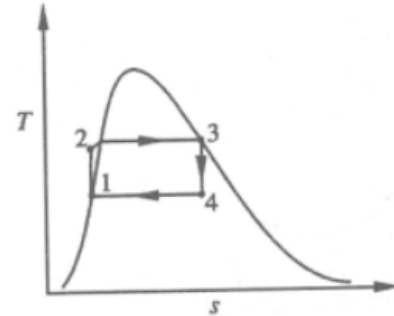
Ans. B

An isolate system does not exchange either energy or mass outside the boundaries of the system.  
Search Tag: ESE 2018

**143.** Statement (I): Rankine efficiency of a steam power plant increases in winter compared to summer.

Statement (II): The increase in Rankine efficiency is due to lower condenser temperature.

Ans. A



$$\eta_r = \frac{(h_3 - h_4) - (h_2 - h_1)}{h_3 - h_2}$$

Decreasing a condenser temperature,  $h_3 - h_4$  increases, hence efficiency decrease.

Search Tag: ESE 2018

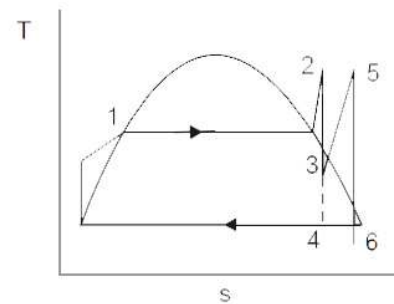
**144.** Statement (I): Direct condensers are more efficient than surface condensers.  
Statement (II): In condenser, the momentum pressure drop opposes the frictional pressure drop.

Ans. C

Sol. The momentum pressure drop decreases the frictional pressure drop.  
Search Tag: ESE 2018

**145.** Statement (I): Reheating between the high-pressure and low-pressure turbines increases the turbine work output.  
Statement (II): The constant pressure lines on T-s diagram diverge away from the origin.

Ans. A



The constant pressure lines on T-s diagram diverge away from the origin. Please ref. the line 5 to 6 it is diverging away from the origin. Hence, the correct explanation for the increasing of the work done.

Search Tag: ESE 2018

- 146.** Statement (I): If a boat, built with sheet metal on wooden frame, has an average density which is greater than that of water, then the boat can float in water with its hollow face upward but will sink once it overturns.  
Statement (II): Buoyant force always acts in the upward direction.

Ans. B

Sol. When it overturns, the meta centre of the boat comes near to the center of gravity and it reaches in between center of Buoyancy and the center of gravity, which is unstable condition.  
Search Tag: ESE 2018

- 147.** Statement (I): In air-blast injection, a separate compressor is used to create an air blast at a pressure of 6 MPa.  
Statement (II): The solid injection system is heavier as it needs increasing the fuel pressure to 30 MPa.

Ans. B

Sol. Both statements are correct, but why a separate compressor is used in air blast is not explained.  
Search Tag: ESE 2018

- 148.** Statement (I): In air-conditioning, the atmospheric air (mixture of dry air and water vapour) can be considered as mixture of two ideal gases.  
Statement (II): In the temperature range used in air-conditioning, the partial pressure of the water vapour is very low and it follows the ideal gas relation with negligible error.

Ans. A

Sol. Both statements are correct, and the statement 2 is the correct explanation, why atmospheric air is considered as a mixture of two ideal gas.

Search Tag: ESE 2018

- 149.** Statement (I): A dynamically balanced system of multiple rotors on a shaft can rotate smoothly at the critical speeds of the system.  
Statement (II): Dynamic balancing eliminates all the unbalanced forces and couples from the system.

Ans. A

Sol. Dynamic balancing eliminates all the unbalanced forces and couples. This can rotate smoothly at the critical speeds of the system, because there is no eccentric mass in balanced system, which causes the infinite deflection at critical speed.

Search Tag: ESE 2018

- 150.** Statement (I): Referring to vapour compression refrigeration system, the coefficient of performance (COP) of a domestic refrigerator is less than that of a comfort air-conditioning plant.

Statement (II): In domestic refrigerator, the work required for pumping the same amount of heat is more than that in an air-conditioning plant because of greater difference between condenser and evaporator temperatures.

Ans. A

Sol. As we know that the coefficient of performance is:

$$COP = \frac{T_L}{T_H - T_L} = \frac{1}{\frac{T_H}{T_L} - 1} = \frac{1}{\frac{\text{Condenser Temp}}{\text{Evaporator Temp}} - 1}$$

The domestic refrigerator has lower evaporator temperature compare to the air conditioning, which makes the dominator  $\frac{\text{Condenser Temp}}{\text{Evaporator Temp}} - 1$  high.

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