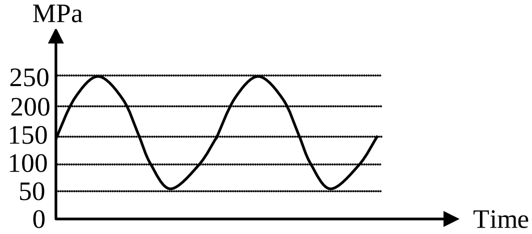
Q. 1 – Q. 25 carry one mark each.

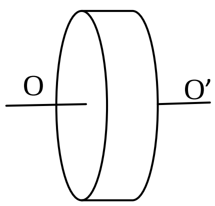
Q.1 For the given fluctuating fatigue load, the values of stress amplitude and stress ratio are respectively



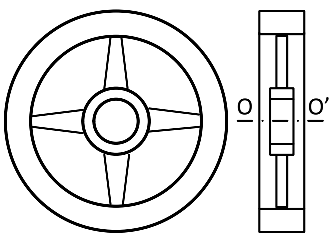
(A) 100 MPa and 5
(B) 250 MPa and 5
(C) 100 MPa and 0.20
(D) 250 MPa and 0.20

Q.2 For the same material and the mass, which of the following configurations of flywheel will have maximum mass moment of inertia about the axis of rotation OO′ passing through the center of gravity.

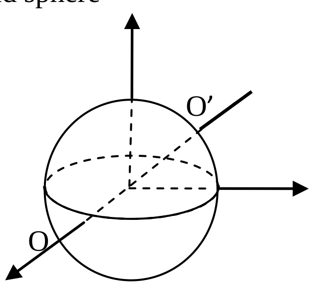
(A) Solid Cylinder



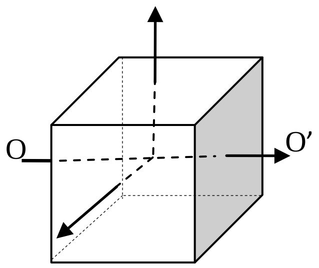
(B) Rimmed wheel



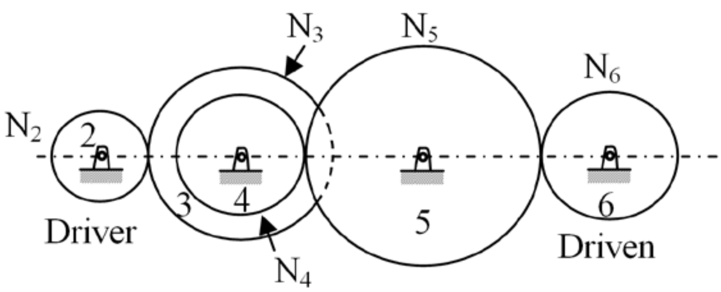
(C) Solid sphere



(D) Solid cube

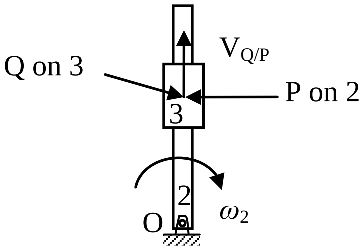


Q.3 A gear train is made up of five spur gears as shown in the figure. Gear 2 is driver and gear 6 is driven member. N_2, N_3, N_4, N_5 and N_6 represent number of teeth on gears 2, 3, 4, 5, and 6 respectively. The gear(s) which act(s) as idler(s) is/are



(A) Only 3
(B) Only 4
(C) Only 5
(D) Both 3 and 5

Q.4 In the figure, link 2 rotates with constant angular velocity ω_2. A slider link 3 moves outwards with a constant relative velocity $V_{Q/P}$, where Q is a point on slider 3 and P is a point on link 2. The magnitude and direction of Coriolis component of acceleration is given by



(A) 2 $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of ω_2

(B) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of ω_2

(C) 2 $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2

(D) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2

Q.5 The strain hardening exponent n of stainless steel SS 304 with distinct yield and UTS values undergoing plastic deformation is

(A) $n < 0$ (B) $n = 0$ (C) $0 < n < 1$ (D) $n = 1$

Q.6 In a machining operation, if the generatrix and directrix both are straight lines, the surface obtained is

(A) cylindrical (B) helical (C) plane (D) surface of revolution

Q.7 In full mould (cavity-less) casting process, the pattern is made of

(A) expanded polystyrene (B) wax
(C) epoxy (D) plaster of Paris

Q.8 In the notation (a/b/c) : (d/e/f) for summarizing the characteristics of queueing situation, the letters ‘b’ and ‘d’ stand respectively for

(A) service time distribution and queue discipline
(B) number of servers and size of calling source
(C) number of servers and queue discipline
(D) service time distribution and maximum number allowed in system

Q.9 Couette flow is characterized by

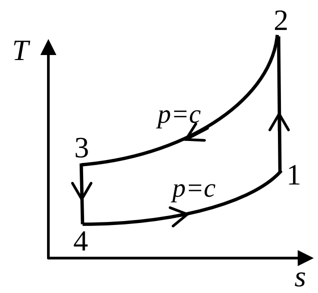
(A) steady, incompressible, laminar flow through a straight circular pipe

(B) fully developed turbulent flow through a straight circular pipe

(C) steady, incompressible, laminar flow between two fixed parallel plates

(D) steady, incompressible, laminar flow between one fixed plate and the other moving with a constant velocity

Q.10 The thermodynamic cycle shown in figure (T-s diagram) indicates



(A) reversed Carnot cycle
(B) reversed Brayton cycle
(C) vapor compression cycle
(D) vapor absorption cycle

Q.11 The ratio of momentum diffusivity (ν) to thermal diffusivity (α), is called

(A) Prandtl number
(B) Nusselt number
(C) Biot number
(D) Lewis number

Q.12 Saturated vapor is condensed to saturated liquid in a condenser. The heat capacity ratio is $C_r = \frac{C_{min}}{C_{max}}$. The effectiveness (ε) of the condenser is

(A) $\frac{1-\exp[-NTU(1+C_r)]}{1+C_r}$
(B) $\frac{1-\exp[-NTU(1-C_r)]}{1-C_r\exp[-NTU(1-C_r)]}$
(C) $\frac{NTU}{1+NTU}$
(D) $1-\exp(-NTU)$

Q.13 Using a unit step size, the value of integral $\int_1^2 x\ln x\,dx$ by trapezoidal rule is ________

Q.14 If P(X) = 1/4, P(Y) = 1/3, and P(X ∩ Y) = 1/12, the value of P(Y/X) is

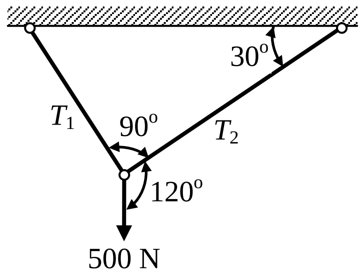
(A) $\frac{1}{4}$
(B) $\frac{4}{25}$
(C) $\frac{1}{3}$
(D) $\frac{29}{50}$

Q.15 The lowest eigenvalue of the 2×2 matrix $\begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$ is ________

Q.16 The value of $\lim_{x\to 0}\left(\frac{-\sin x}{2\sin x + x\cos x}\right)$ is ________

Q.17 A cylindrical tank with closed ends is filled with compressed air at a pressure of 500 kPa. The inner radius of the tank is 2 m, and it has wall thickness of 10 mm. The magnitude of maximum in-plane shear stress (in MPa) is ________

Q.18 A weight of 500 N is supported by two metallic ropes as shown in the figure. The values of tensions T_1 and T_2 are respectively



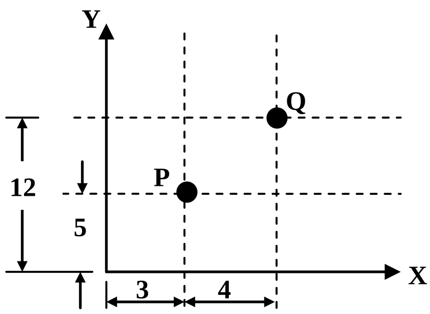
(A) 433 N and 250 N
(B) 250 N and 433 N
(C) 353.5 N and 250 N
(D) 250 N and 353.5 N

Q.19 Which of the following statements are **TRUE** for damped vibrations?

P. For a system having critical damping, the value of damping ratio is unity and system does not undergo a vibratory motion.
Q. Logarithmic decrement method is used to determine the amount of damping in a physical system.
R. In case of damping due to dry friction between moving surfaces resisting force of constant magnitude acts opposite to the relative motion.
S. For the case of viscous damping, drag force is directly proportional to the square of relative velocity.

(A) P and Q only
(B) P and S only
(C) P, Q and R only
(D) Q and S only

Q.20 A drill is positioned at point P and it has to proceed to point Q. The coordinates of point Q in the incremental system of defining position of a point in CNC part program will be



(A) (3, 12)
(B) (5, 7)
(C) (7, 12)
(D) (4, 7)

Q.21 Which two of the following joining processes are autogeneous?

(i) Diffusion welding
(ii) Electroslag welding
(iii) Tungsten inert gas welding
(iv) Friction welding

(A) (i) and (iv)
(B) (ii) and (iii)
(C) (ii) and (iv)
(D) (i) and (iii)

Q.22 Three parallel pipes connected at the two ends have flow-rates Q_1, Q_2 and Q_3 respectively, and the corresponding frictional head losses are h_{L1}, h_{L2} and h_{L3} respectively. The correct expressions for total flow rate (Q) and frictional head loss across the two ends (h_L) are

(A) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(B) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$
(C) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(D) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$

Q.23 A rigid container of volume 0.5 m^3 contains 1.0 kg of water at 120°C (v_f = 0.00106 m^3/kg, v_g= 0.8908 m^3/kg). The state of water is

(A) compressed liquid
(B) saturated liquid
(C) a mixture of saturated liquid and saturated vapor
(D) superheated vapor

Q.24 Let ϕ be an arbitrary smooth real valued scalar function and $\vec{V}$ be an arbitrary smooth vector valued function in a three-dimensional space. Which one of the following is an identity?

(A) $\mathrm{Curl}\left(\phi\vec{V}\right)=\nabla\left(\phi\ \mathrm{Div}\vec{V}\right)$

(B) $\mathrm{Div}\vec{V}=0$

(C) $\mathrm{Div\ Curl}\vec{V}=0$

(D) $\mathrm{Div}\left(\phi\vec{V}\right)=\phi\ \mathrm{Div}\vec{V}$

Q.25 An air-standard Diesel cycle consists of the following processes:
1-2: Air is compressed isentropically.
2-3: Heat is added at constant pressure.
3-4: Air expands isentropically to the original volume.
4-1: Heat is rejected at constant volume.
If γ and T denote the specific heat ratio and temperature, respectively, the efficiency of the cycle is

(A) $1-\dfrac{T_4-T_1}{T_3-T_2}$

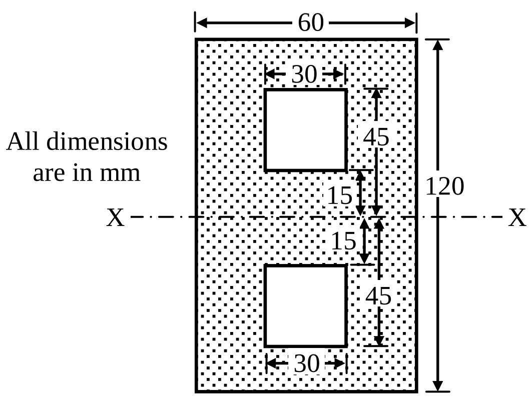
(B) $1-\dfrac{T_4-T_1}{\gamma\left(T_3-T_2\right)}$

(C) $1-\dfrac{\gamma\left(T_4-T_1\right)}{T_3-T_2}$

(D) $1-\dfrac{T_4-T_1}{\left(\gamma-1\right)\left(T_3-T_2\right)}$

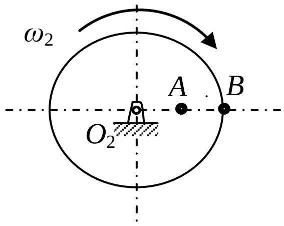
Q. 26 – Q. 55 carry two marks each.

Q.26 The value of moment of inertia of the section shown in the figure about the axis-XX is

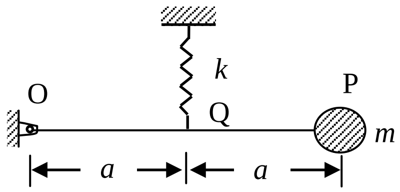


(A) 8.5050×10^6 mm^4
(B) 6.8850×10^6 mm^4
(C) 7.7625×10^6 mm^4
(D) 8.5725×10^6 mm^4

Q.27 Figure shows a wheel rotating about O_2. Two points A and B located along the radius of wheel have speeds of 80 m/s and 140 m/s respectively. The distance between the points A and B is 300 mm. The diameter of the wheel (in mm) is ________



Q.28 Figure shows a single degree of freedom system. The system consists of a massless rigid bar OP hinged at O and a mass m at end P. The natural frequency of vibration of the system is



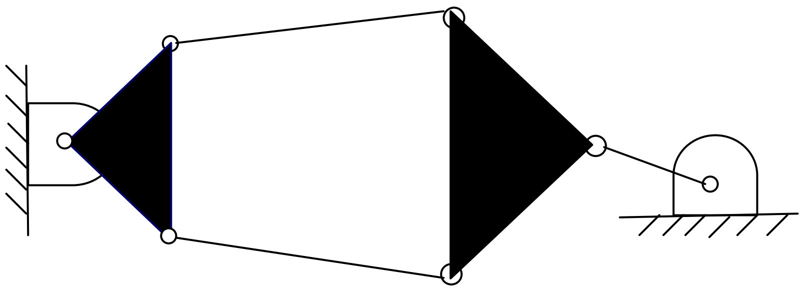
(A) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{4m}}$

(B) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{2m}}$

(C) $f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

(D) $f_n = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$

Q.29 The number of degrees of freedom of the linkage shown in the figure is



(A) −3 (B) 0 (C) 1 (D) 2

Q.30 For ball bearings, the fatigue life L measured in number of revolutions and the radial load F are related by $FL^{1/3} = K$, where K is a constant. It withstands a radial load of 2 kN for a life of 540 million revolutions. The load (in kN) for a life of one million revolutions is ________

Q.31 In a rolling operation using rolls of diameter 500 mm, if a 25 mm thick plate cannot be reduced to less than 20 mm in one pass, the coefficient of friction between the roll and the plate is ________

Q.32 Ratio of solidification time of a cylindrical casting (height = radius) to that of a cubic casting of side two times the height of cylindrical casting is ________

Q.33 The annual requirement of rivets at a ship manufacturing company is 2000 kg. The rivets are supplied in units of 1 kg costing Rs. 25 each. If it costs Rs. 100 to place an order and the annual cost of carrying one unit is 9% of its purchase cost, the cycle length of the order (in days) will be ________

Q.34 Orthogonal turning of a mild steel tube with a tool of rake angle 10° is carried out at a feed of 0.14 mm/rev. If the thickness of the chip produced is 0.28 mm, the values of shear angle and shear strain will be respectively

(A) 28°20′ and 2.19 (B) 22°20′ and 3.53 (C) 24°30′ and 4.19 (D) 37°20′ and 5.19

Q.35 In a CNC milling operation, the tool has to machine the circular arc from point (20, 20) to (10, 10) at sequence number 5 of the CNC part program. If the center of the arc is at (20, 10) and the machine has incremental mode of defining position coordinates, the correct tool path command is

(A) N 05 G90 G01 X–10 Y–10 R10

(B) N 05 G91 G03 X–10 Y–10 R10

(C) N 05 G90 G03 X20 Y20 R10

(D) N 05 G91 G02 X20 Y20 R10

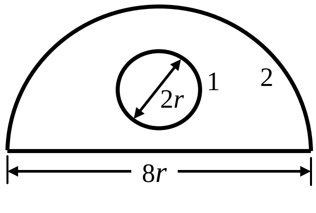
Q.36 A Prandtl tube (Pitot-static tube with C=1) is used to measure the velocity of water. The differential manometer reading is 10 mm of liquid column with a relative density of 10. Assuming g = 9.8 m/s^2, the velocity of water (in m/s) is ________

Q.37 Refrigerant vapor enters into the compressor of a standard vapor compression cycle at − 10°C (h = 402 kJ/kg) and leaves the compressor at 50°C (h = 432 kJ/kg). It leaves the condenser at 30°C (h = 237 kJ/kg). The COP of the cycle is ________

Q.38 Steam enters a turbine at 30 bar, 300°C (u = 2750 kJ/kg, h = 2993 kJ/kg) and exits the turbine as saturated liquid at 15 kPa (u = 225 kJ/kg, h = 226 kJ/kg). Heat loss to the surrounding is 50 kJ/kg of steam flowing through the turbine. Neglecting changes in kinetic energy and potential energy, the work output of the turbine (in kJ/kg of steam) is ________

Q.39 Air in a room is at 35°C and 60% relative humidity (RH). The pressure in the room is 0.1 MPa. The saturation pressure of water at 35°C is 5.63 kPa. The humidity ratio of the air (in gram/kg of dry air) is ________

Q.40 A solid sphere 1 of radius ‘r’ is placed inside a hollow, closed hemispherical surface 2 of radius ‘4r’. The shape factor $F_{2\text{-}1}$ is



(A) 1/12 (B) 1/2 (C) 2 (D) 12

Q.41 The value of

$\int_C [(3x - 8y^2)\mathrm{d}x + (4y - 6xy)\mathrm{d}y]$, (where C is the boundary of the region bounded by $x = 0$, $y = 0$ and $x+y = 1$) is ________

Q.42 For a given matrix P = $\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$, where $i = \sqrt{-1}$, the inverse of matrix P is

(A) $\frac{1}{24}\begin{bmatrix} 4-3i & i \\ -i & 4+3i \end{bmatrix}$

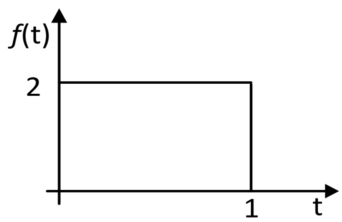
(B) $\frac{1}{25}\begin{bmatrix} i & 4-3i \\ 4+3i & -i \end{bmatrix}$

(C) $\frac{1}{24}\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$

(D) $\frac{1}{25}\begin{bmatrix} 4+3i & -i \\ i & 4-3i \end{bmatrix}$

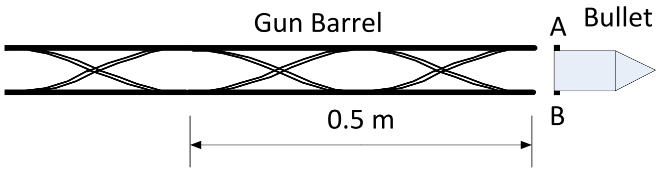
Q.43 Newton-Raphson method is used to find the roots of the equation, $x^3 + 2x^2 + 3x - 1 = 0$. If the initial guess is $x_0 = 1$, then the value of x after 2nd iteration is ________

Q.44 Laplace transform of the function $f(t)$ is given by $F(s) = L\{f(t)\} = \int_0^\infty f(t)e^{-st}\mathrm{d}t$.
Laplace transform of the function shown below is given by



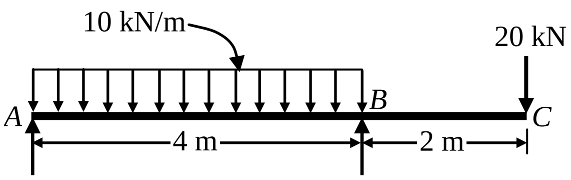
(A) $\frac{1-e^{-2s}}{s}$ (B) $\frac{1-e^{-s}}{2s}$ (C) $\frac{2-2e^{-s}}{s}$ (D) $\frac{1-2e^{-s}}{s}$

Q.45 A bullet spins as the shot is fired from a gun. For this purpose, two helical slots as shown in the figure are cut in the barrel. Projections A and B on the bullet engage in each of the slots.



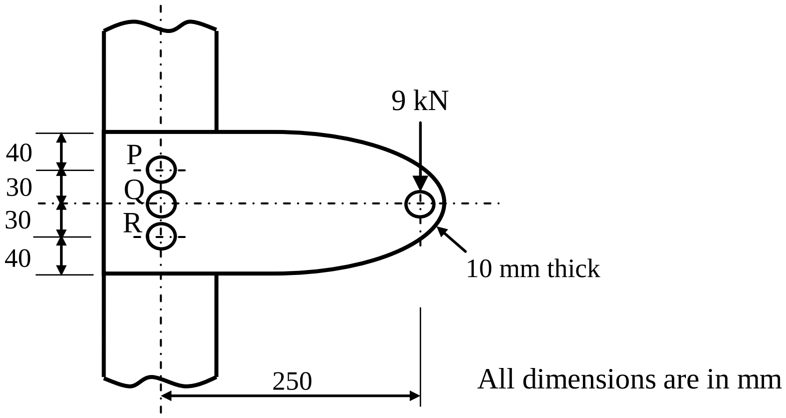
Helical slots are such that one turn of helix is completed over a distance of 0.5 m. If velocity of bullet when it exits the barrel is 20 m/s, its spinning speed in rad/s is ________

Q.46 For the overhanging beam shown in figure, the magnitude of maximum bending moment (in kN-m) is ________



Q.47 The torque (in N-m) exerted on the crank shaft of a two stroke engine can be described as $T = 10000 + 1000 \sin 2\theta - 1200 \cos 2\theta$, where θ is the crank angle as measured from inner dead center position. Assuming the resisting torque to be constant, the power (in kW) developed by the engine at 100 rpm is ________

Q.48 A cantilever bracket is bolted to a column using three M12×1.75 bolts P, Q and R. The value of maximum shear stress developed in the bolt P (in MPa) is ________



Q.49 A shaft of length 90 mm has a tapered portion of length 55 mm. The diameter of the taper is 80 mm at one end and 65 mm at the other. If the taper is made by tailstock set over method, the taper angle and the set over respectively are

(A) 15°32′ and 12.16 mm
(B) 18°32′ and 15.66 mm
(C) 11°22′ and 10.26 mm
(D) 10°32′ and 14.46 mm

Q.50 The dimensions of a cylindrical side riser (height = diameter) for a 25 cm × 15 cm × 5 cm steel casting are to be determined. For the tabulated shape factor values given below, the diameter of the riser (in cm) is ________

Shape factor	2	4	6	8	10	12
Riser volume/ Casting volume	1.0	0.70	0.55	0.50	0.40	0.35

Q.51 For the linear programming problem:

Maximize $Z = 3X_1 + 2X_2$

Subject to

$-2X_1 + 3X_2 \leq 9$

$X_1 - 5X_2 \geq -20$

$X_1, X_2 \geq 0$

The above problem has

(A) unbounded solution
(B) infeasible solution
(C) alternative optimum solution
(D) degenerate solution

Q.52 Which of the following statements are **TRUE**, when the cavitation parameter $\sigma = 0$?

(i) the local pressure is reduced to vapor pressure
(ii) cavitation starts
(iii) boiling of liquid starts
(iv) cavitation stops

(A) (i), (ii) and (iv)
(B) only (ii) and (iii)
(C) only (i) and (iii)
(D) (i), (ii) and (iii)

Q.53 One side of a wall is maintained at 400 K and the other at 300 K. The rate of heat transfer through the wall is 1000 W and the surrounding temperature is 25°C. Assuming no generation of heat within the wall, the irreversibility (in W) due to heat transfer through the wall is ________

Q.54 A brick wall $\left(k = 0.9\frac{W}{m.K}\right)$ of thickness 0.18 m separates the warm air in a room from the cold ambient air. On a particular winter day, the outside air temperature is -5°C and the room needs to be maintained at 27°C. The heat transfer coefficient associated with outside air is $20\frac{W}{m^2K}$. Neglecting the convective resistance of the air inside the room, the heat loss, in $\left(\frac{W}{m^2}\right)$, is

(A) 88 (B) 110 (C) 128 (D) 160

Q.55 A mixture of ideal gases has the following composition by mass:

N_2	O_2	CO_2
60%	30%	10%

If the universal gas constant is 8314 J/kmol-K, the characteristic gas constant of the mixture (in J/kg-K) is ________

END OF THE QUESTION PAPER