Assignment 8

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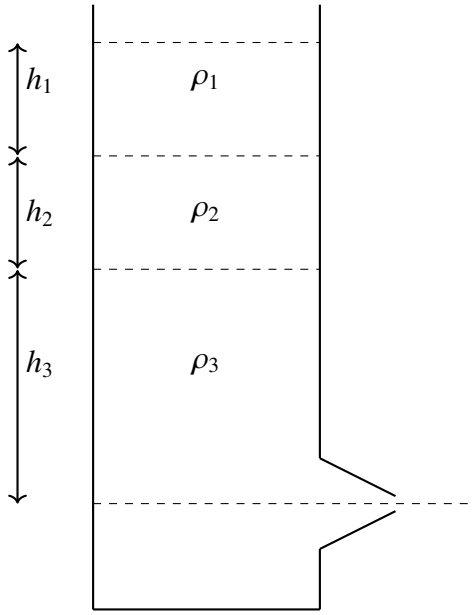
GATE-2012:ME

1) A large tank with a nozzle attached contains three immiscible, inviscid fluids as shown. Assuming that the changes in h_1, h_2 and h_3 are negligible, the instantaneous discharge velocity is



(ME:2012)

a) $\sqrt{2g\left(\frac{\rho_1 h_1+\rho_2 h_2+\rho_3 h_3}{\rho_3 h_3}\right)}$

b) $\sqrt{2g(h_1+h_2+h_3)}$

c) $\sqrt{2g(\frac{\rho_1 h_1+\rho_2 h_2+\rho_3 h_3}{\rho_1+\rho_2+\rho_3})}$

d) $\sqrt{2g(\frac{\rho_1 h_2 h_3+\rho_2 h_1 h_3+\rho_3 h_1 h_2}{\rho_1 h_1+\rho_2 h_2+\rho_3 h_3})}$

2) Water ($C_p = 4.18\,kJ/kg.K$) at $80°C$ enters a counterflow heat exchanger with a mass flow rate of $0.5\,kg/s$. Air ($C_p = 1\,kJ/kg.K$) enters at $30°C$ with a mass flow rate of $2.09\,kg/s$. If the effectiveness of the heat exchanger is 0.8, the LMTD (in $°C$) is

(ME:2012)

a) 40 b) 20 c) 10 d) 5

3) A solid steel cube constrained on all six faces is heated so that the temperature rises uniformly by ΔT. If the thermal coefficient of the material is α, Young's modulus is E and the Poisson's ratio is ν, the thermal stress developed in the cube due to heating is

(ME:2012)

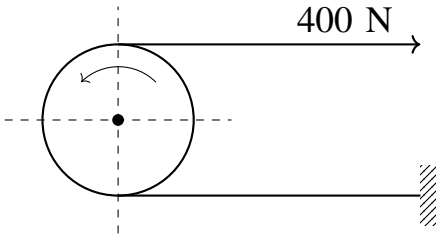
a) $-\frac{\alpha E \Delta T}{(1-2\nu)}$ b) $-\frac{2\alpha E \Delta T}{(1-2\nu)}$ c) $-\frac{3\alpha E \Delta T}{(1-2\nu)}$ d) $-\frac{\alpha E \Delta T}{3(1-2\nu)}$

4) A solid circular shaft needs to be designed to transmit a torque of $50\,N.m$. If the allowable shear stress of the material is $140\,MPa$, assuming a factor of safety of 2, the minimum allowable design diameter in *mm* is

(ME:2012)

a) 8 b) 16 c) 24 d) 32

5) A force of $400\,N$ is applied to the brake drum of $0.5\,m$ diameter in a band-brake system as shown in the figure, where the wrapping angle is 180°. If the coefficient of friction between the drum and the band is 0.25, the braking torque applied, in *N.m* is



(ME:2012)

a) 100.6 b) 54.4 c) 22.1 d) 15.7

6) A box contains 4 red balls and 6 black balls. Three balls are selected randomly from the box one after another, without replacement. The probability that the selected set contains one red ball and two black balls is

(ME:2012)

a) $\frac{1}{20}$ b) $\frac{1}{12}$ c) $\frac{3}{10}$ d) $\frac{1}{2}$

7) Consider the differential equation $x^2\frac{d^2y}{dx^2} + 4x\frac{dy}{dx} - 4y = 0$ with the boundary conditions of $y(0) = 0$ and $y(1) = 1$. The complete solution of the differential equation is

(ME:2012)

a) x^2 b) $\sin(\frac{\pi x}{2})$ c) $e^x \sin(\frac{\pi x}{2})$ d) $e^{-x} \sin(\frac{\pi x}{2})$

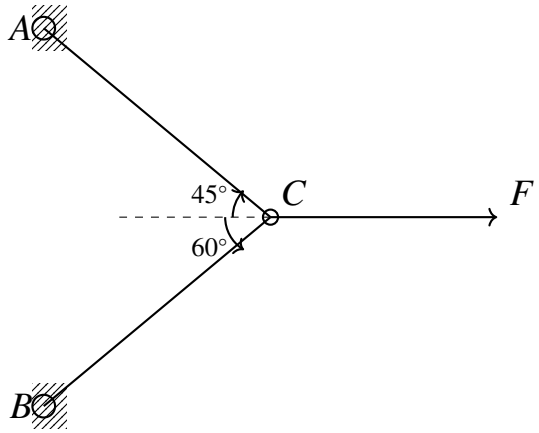
8) $x + 2y + z = 4$
$2x + y + 2z = 5$
$x - y + z = 1$
The system of algebraic equations given above has

(ME:2012)

a) a unique solution of $x = 1, y = 1$ and $z = 1$.
b) only the two solutions of $(x = 1, y = 1, z = 1)$ and $(x = 2, y = 1, z = 0)$.
c) infinite number of solutions.
d) no feasible solution.

Common data for questions 9 and 10

Two steel truss members, *AC* and *BC*, each having cross-sectional area of $100\,mm^2$, are subjected to a horizontal force F as shown in figure. All the joints are hinged.



(ME:2012)

9) If $F = 1\,kN$, the magnitude of the vertical reaction force developed at the point B in kN is

a) 0.63 b) 0.32 c) 1.26 d) 1.46

10) The maximum force F in kN that can be applied at C such that the axial stress in any of the truss members DOES NOT exceed $100\,MPa$ is

a) 8.17 b) 11.15 c) 14.14 d) 22.30

Common data for questions 11 and 12

A refrigerator operates between $120\,kPa$ and $800\,kPa$ in an ideal vapor compression cycle with $R-134a$ as the refrigerant. The refrigerant enters the compressor as saturated vapor and leaves the condenser as saturated liquid. The mass flow rate of the refrigerant is $0.2\,kg/s$. Properties for $R-134a$ are as follows:

Saturated R-134a Properties

P (kPa)	T (°C)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg·K)	s_g (kJ/kg·K)
120	-22.32	22.5	237	0.093	0.95
800	31.31	95.5	267.3	0.354	0.918

Superheated R-134a Properties

P (kPa)	T (°C)	h (kJ/kg)	s (kJ/kg·K)
800	40	276.45	0.95

(ME:2012)

11) The rate at which heat is extracted, in kJ/s from the refrigerated space is

a) 28.3 b) 42.9 c) 34.4 d) 14.6

12) The power required for the compressor in kW is

a) 5.94 b) 1.83 c) 7.9 d) 39.5

Linked Answer Questions:

Air enters an adiabatic nozzle at $300\,kPa, 500\,K$ with a velocity of $10\,m/s$. It leaves the nozzle

at $100\,kPa$ with a velocity of $180\,m/s$. The inlet area is $80\,cm^2$. The specific heat of air C_p is $1008\,J/kg.K$.

(ME:2012)

13) The exit temperature of the air is

a) $516\,K$ b) $532\,K$ c) $484\,K$ d) $468\,K$