L-3/T-1/ME **Date: 01/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

Sub: **ME 305** (Heat Transfer)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Assume reasonable value for any missing data. The symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Consider a spherical container of inner radius r_1 = 8 cm, outer radius r_2 = 10 cm, and thermal conductivity k = 45 W/m.°C, as shown in the Figure for Q-1(a). The inner and outer surfaces of the container are maintained at constant temperatures of T_1 = 200°C and T_2 = 80°C, respectively, as a result of some chemical reactions occurring inside. Obtain a general relation for the temperature distribution inside the shell under steady conditions, and determine the rate of heat loss from the container. **(17)**

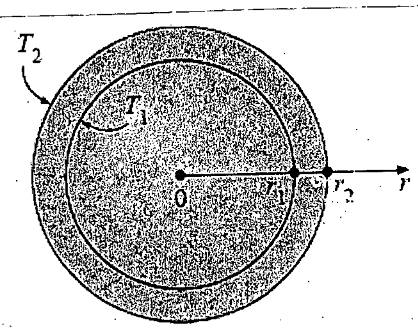

Figure for Q-1(a)

(b) The wall of a refrigerator is constructed of fiber glass insulation (k = 0.035 W/m.°C) sandwiched between two layers of of 1-mm-thick sheet metal (k = 15.1 W/m.°C). The refrigerated space is maintained at 3°C, and the average heat transfer coefficients at the inner and outer surfaces of the wall are 4 W/m^2.°C and 9 W/m^2.°C, respectively. The kitchen temperature averages 25°C. It is observed that condensation occurs on the outer surfaces of the refrigerator when the temperature of the outer surface drops to 20°C. Determine the minimum thickness of fiberglass insulation that needs to be used in the wall in order to avoid condensation on the outer surfaces. **(18)**

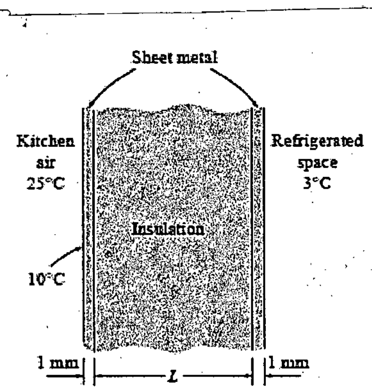

Figure for Q-1(b)

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2. (a) A 30-m-long, 10-cm-diameter hot water pipe of a district heating system is buried in the soil 50 cm below the ground surface. The outer surface temperature of the pipe is 80°C. Taking the surface temperature of the earth to be 10°C and the thermal conductivity of the soil at that location to be 0.9 W/m.°C, determine the rate of heat loss from the pipe. **(10)**

(b) An ordinary egg can be approximated as a 5.5-cm diameter sphere whose properties are roughly k = 0.6 W/m.°C and $\alpha = 0.14 \times 10^{-6}$ m^2/s. The egg is initially at a uniform temperature of 8°C and is dropped into boiling water at 97°C. Taking the convection heat transfer coefficient to be h = 1400 W/m^2.°C, determine how long it will take for the center of the egg to reach 70°C. **(17)**

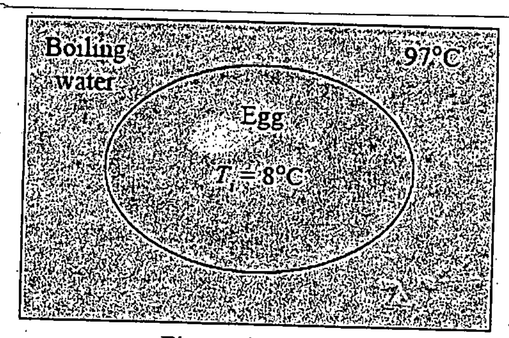

Figure for Q-2(b)

(c) Consider steady heat conduction in a plane wall whose left surface (node 0) is maintained at 30°C while the right surface (node 8) is subjected to a heat flux of 800 W/m^2. Express the finite difference formulation of the boundary nodes 0 to 8. **(8)**

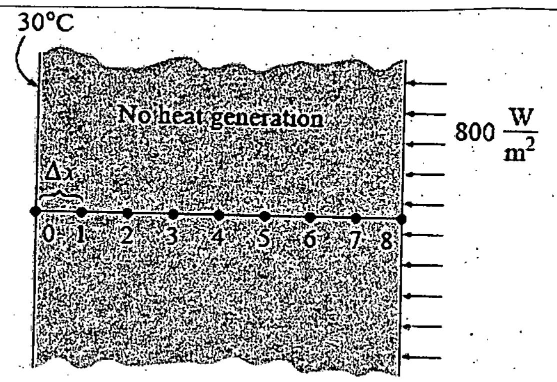

Figure for Q-2(c)

3. (a) Draw the boiling curve and identify the burnout point on the curve. Explain how burnout is caused. Why is the burnout point avoided in the design of boilers? **(10)**

(b) The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of horizontal pipes through which cooling water circulates. The condenser consists of 12 horizontal tubes arranged in a

Contd P/3

Contd... Q. No. 3(b)

rectangular array of 3 tubes high and 4 tubes wide, as shown in Figure for Q 3(b). The outer diameter of the pipe is 3 cm, and the outer surfaces of the pipes are maintained at 30°C. Determine: (i) The rate of heat transfer to the cooling water circulating in the pipes and (ii) the rate of condensation of steam per unit length of a horizontal pipe. **(25)**

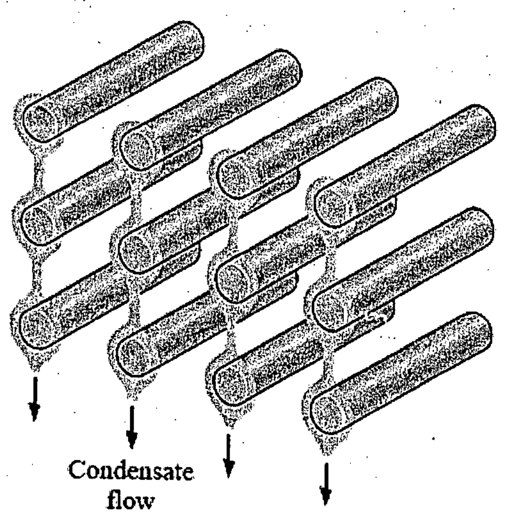

Figure for Q-3(b)

4. (a) A small surface of area $A_1 = 4$ cm^2 emits radiation as a black body at $T_1 = 800$ K. Part of the radiation emitted by A_1 strikes another small surface of area A_2 = 4 cm^2 oriented as shown in the figure for Q 4(a). Determine the solid angle subtended by A_2 when viewed from A_1, and the rate at which radiation emitted by A_1 that strikes A_2 directly. What would your answer be if A_2 were directly above A_1 at a distance of 80 cm? **(15)**

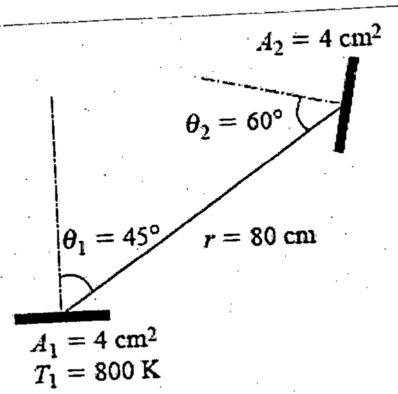

Figure for Q-4(a)

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Contd... Q. No. 4

(b) A furnace is shaped like a long equilateral triangular duct, as shown in the figure for Q 4(b). The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600 K. The heated left-side surface closely approximates a blackbody at 1000 K. The right-side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions. **(20)**

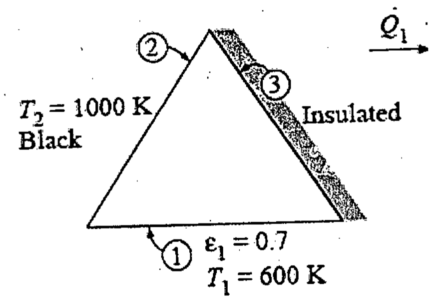

Fig. for Q-4(b)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Explain the mechanism of convection heat transfer. **(5)**

(b) Write down the governing equations in non-dimensional form for forced convection over a horizontal flat plate. State necessary assumptions. Simplify those equations using boundary layer approximation. **(10)**

(c) A 6-cm diameter shaft rotates at 3000 rpm in a 20-cm long bearing with a uniform clearance of 0.2 mm. At steady operating conditions, both the bearing and the shaft in the vicinity of the oil gap are at 50°C, and the viscosity and thermal conductivity of lubricating oil are 0.05 N.s/m^2 and 0.17 W/m.K. By simplifying and solving the continuity, momentum, and energy equations, determine the maximum temperature of oil and the rate of heat transfer to the shaft. **(20)**

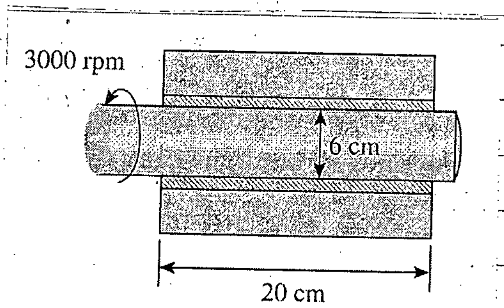

Fig. for Q. No. 5(c)

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6. (a) The forming section of a plastics plant puts out a continuous sheet of plastic that is 1.2 m wide and 2 mm thick at a rate of 15 m/min. The temperature of the plastic sheet is 90°C when it is exposed to the surrounding air, and the sheet is subjected to air flow at 30°C at a velocity of 3 m/s on both sides along its surfaces normal to the direction of motion of the sheet. The width of the air cooling section is such that a fixed point on the plastic sheet passes through that section in 2s. Determine the rate of heat transfer from the plastic sheet to the air. **(18)**

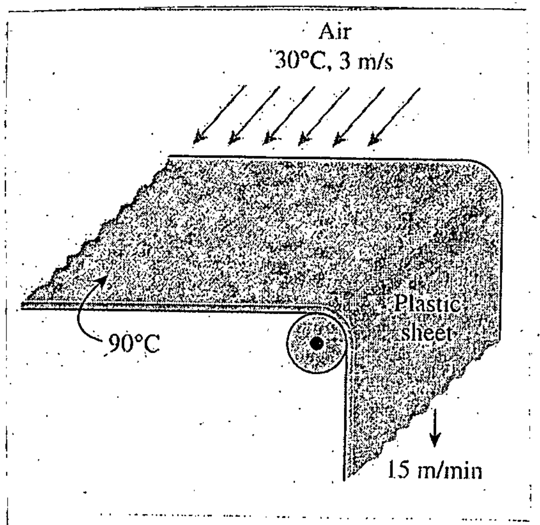

Fig. for Q. No. 6(a)

(b) In a parabolic trough concentrator, solar energy is collected by placing a tube at the focal line of the collector and passing fluid through the tube. The arrangement resulting in a uniform heat flux of 2000 W/m^2 along the axis of the tube of diameter 60 mm. Calculate (i) the length of the tube required to heat water from 20°C to 80°C, which flows at the rate of 0.01 kg/s and (ii) the surface temperature at the outlet of the tube. **(17)**

7. (a) Draw the temperature and the velocity distributions in the vicinity of a heated flat plate placed vertically in a quiescent water tank. **(7)**

(b) Identify the cases of effective and ineffective heat transfer with proper sketch during natural convection on horizontal hot and cold plates. **(8)**

(c) A 28-cm-high, 18-cm-long, and 18-cm-wide rectangular container suspended in a room at 24°C is initially filled with cold water at 2°C. The surface temperature of the container is observed to be nearly the same as the water temperature inside. The emissivity of the container surface is 0.6, and the temperature of the surrounding surfaces is about the same as the air temperature. Determine the water temperature in the container after 3 hours, and the average rate of heat transfer to the water. Assume the heat transfer coefficient on the top and the bottom surfaces to be the same as that on the side surfaces. **(20)**

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8. (a) State Fick's law of diffusion. For a binary gas mixture in a closed chamber, explain the process of mass transfer by diffusion with necessary mathematical expressions. **(7)**

(b) Define Schmidt, Prandtl and Lewis numbers. Explain their physical significances in relation to boundary layer development. **(8)**

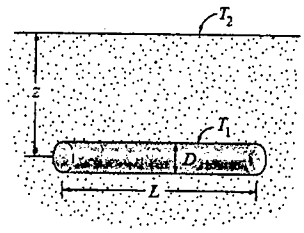
(c) Dry air at atmospheric pressure blows across a thermometer which is enclosed in a dampened cover. This is the classical wet-bulb thermometer. The thermometer reads a temperature of $T_w = 18.3°C$. Using the relation between heat and mass transfer, derive an expression for determination of the temperature of the dry air. What is the temperature of the dry air? Given that molecular weights of dry air and water are 28.96 and 18.02 g/mol, respectively. **(20)**

Chart for Shape Factor

Conduction shape factors S for several configurations for use in $\dot{Q} = kS(T_1 - T_2)$ to determine the steady rate of heat transfer through a medium of thermal conductivity k between the surfaces at temperatures T_1 and T_2

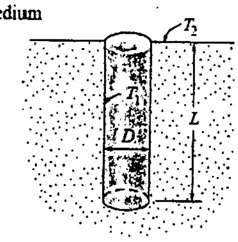
(1) Isothermal cylinder of length L buried in a semi-infinite medium ($L >> D$ and $z > 1.5D$)

$$S = \frac{2\pi L}{\ln(4z/D)}$$



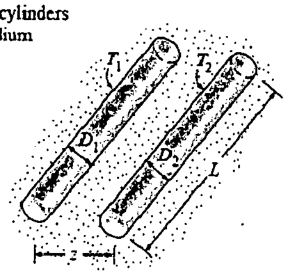
(2) Vertical isothermal cylinder of length L buried in a semi-infinite medium ($L >> D$)

$$S = \frac{2\pi L}{\ln(4L/D)}$$



(3) Two parallel isothermal cylinders placed in an infinite medium ($L >> D_1, D_2, z$)

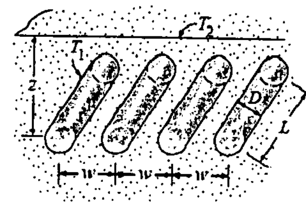
$$S = \frac{2\pi L}{\cosh^{-1}\left(\frac{4z^2 - D_1^2 - D_2^2}{2D_1 D_2}\right)}$$



(4) A row of equally spaced parallel isothermal cylinders buried in a semi-infinite medium ($L >> D$, z and $w > 1.5D$)

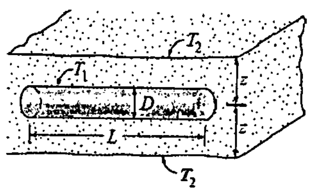
$$S = \frac{2\pi L}{\ln\left(\frac{2w}{\pi D}\sinh\frac{2\pi z}{w}\right)}$$

(per cylinder)



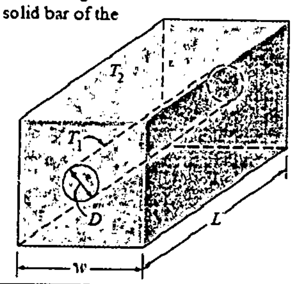
(5) Circular isothermal cylinder of length L in the midplane of an infinite wall ($z > 0.5D$)

$$S = \frac{2\pi L}{\ln(8z/\pi D)}$$



(6) Circular isothermal cylinder of length L at the center of a square solid bar of the same length

$$S = \frac{2\pi L}{\ln(1.08\,w/D)}$$



Coefficient Used in Transient One-Dimensional Heat Conduction

Coefficients used in the one-term approximate solution of transient one-dimensional heat conduction in plane walls, cylinders, and spheres ($Bi = hL/k$ for a plane wall of thickness $2L$, and $Bi = hr_o/k$ for a cylinder or sphere of radius r_o)

	Plane Wall		*Cylinder*		*Sphere*	
Bi	λ_1	A_1	λ_1	A_1	λ_1	A_1
0.01	0.0998	1.0017	0.1412	1.0025	0.1730	1.0030
0.02	0.1410	1.0033	0.1995	1.0050	0.2445	1.0060
0.04	0.1987	1.0066	0.2814	1.0099	0.3450	1.0120
0.06	0.2425	1.0098	0.3438	1.0148	0.4217	1.0179
0.08	0.2791	1.0130	0.3960	1.0197	0.4860	1.0239
0.1	0.3111	1.0161	0.4417	1.0246	0.5423	1.0298
0.2	0.4328	1.0311	0.6170	1.0483	0.7593	1.0592
0.3	0.5218	1.0450	0.7465	1.0712	0.9208	1.0880
0.4	0.5932	1.0580	0.8516	1.0931	1.0528	1.1164
0.5	0.6533	1.0701	0.9408	1.1143	1.1656	1.1441
0.6	0.7051	1.0814	1.0184	1.1345	1.2644	1.1713
0.7	0.7506	1.0918	1.0873	1.1539	1.3525	1.1978
0.8	0.7910	1.1016	1.1490	1.1724	1.4320	1.2236
0.9	0.8274	1.1107	1.2048	1.1902	1.5044	1.2488
1.0	0.8603	1.1191	1.2558	1.2071	1.5708	1.2732
2.0	1.0769	1.1785	1.5995	1.3384	2.0288	1.4793
3.0	1.1925	1.2102	1.7887	1.4191	2.2889	1.6227
4.0	1.2646	1.2287	1.9081	1.4698	2.4556	1.7202
5.0	1.3138	1.2403	1.9898	1.5029	2.5704	1.7870
6.0	1.3496	1.2479	2.0490	1.5253	2.6537	1.8338
7.0	1.3766	1.2532	2.0937	1.5411	2.7165	1.8673
8.0	1.3978	1.2570	2.1286	1.5526	2.7654	1.8920
9.0	1.4149	1.2598	2.1566	1.5611	2.8044	1.9106
10.0	1.4289	1.2620	2.1795	1.5677	2.8363	1.9249
20.0	1.4961	1.2699	2.2880	1.5919	2.9857	1.9781
30.0	1.5202	1.2717	2.3261	1.5973	3.0372	1.9898
40.0	1.5325	1.2723	2.3455	1.5993	3.0632	1.9942
50.0	1.5400	1.2727	2.3572	1.6002	3.0788	1.9962
100.0	1.5552	1.2731	2.3809	1.6015	3.1102	1.9990
∞	1.5708	1.2732	2.4048	1.6021	3.1416	2.0000

Equations for Centerline Temperature

Center of plane wall ($x = 0$): $$\theta_{0,\text{ wall}} = \frac{T_o - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau}$$

Center of cylinder ($r = 0$): $$\theta_{0,\text{ cyl}} = \frac{T_o - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau}$$

Center of sphere ($r = 0$): $$\theta_{0,\text{ sph}} = \frac{T_o - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau}$$

Condensation Heat Transfer Equation for Horizontal Tube Bank

$$h_{\text{horiz, } N \text{ tubes}} = 0.729 \left[\frac{g \rho_l (\rho_l - \rho_v)\, h^*_{fg} k_l^3}{\mu_l (T_{\text{sat}} - T_s)\, ND} \right]^{1/4} = \frac{1}{N^{1/4}} h_{\text{horiz, 1 tube}}$$

Summary of Correlation for Forced Convection Flow over Flat Plates

Properties evaluated at Film temperature

Type	Restrictions	Fluid Flow	Heat Transfer: Isothermal (T_w = constant)	Heat Transfer: Isoflux (q_w = constant)
Local	Laminar: $Re_x < 5 \times 10^5$; $0.6 < Pr < 50$	$C_{f,x} = 0.664 Re_x^{-1/2}$	$Nu_x = 0.332 Re_x^{1/2} Pr^{1/3}$	$Nu_x = 0.453 Re_x^{1/2} Pr^{1/3}$
Average	Laminar: $Re_L < 5 \times 10^5$; $0.6 < Pr < 50$	$C_f = 1.328 Re_L^{-1/2}$	$Nu_L = 0.664 Re_L^{1/2} Pr^{1/3}$	$Nu_L = 0.680 Re_L^{1/2} Pr^{1/3}$
Local	Turbulent: $5 \times 10^5 \le Re_x \le 10^7$; $0.6 \le Pr \le 60$	$C_{f,x} = 0.059 Re_x^{-1/5}$	$Nu_x = 0.0296 Re_x^{4/5} Pr^{1/3}$	$Nu_x = 0.0308 Re_x^{4/5} Pr^{1/3}$
Average	Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; $0.6 \le Pr \le 60$	$C_f = 0.074 Re_L^{-1/5}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$	$Nu_L = 0.037 Re_L^{4/5} Pr^{1/3}$
Average	Partly Laminar, Partly Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; $0.6 \le Pr \le 60$; $Re_{cr} = 5 \times 10^5$	$C_f = 0.074 Re_L^{-1/5} - 1742 Re_L$	$Nu_L = \left(0.037 Re_L^{4/5} - 871\right) Pr^{1/3}$	$Nu_L = \dfrac{0.037 Re_L^{4/5} Pr^{1/3}}{1 + 12.35 \times 10^6 Re_L^{-6/5}}$
Local	All Prandtl number (Churchill and Ozoe): $Pe_x \ge 100$		$Nu_x = \dfrac{0.3387 Re_x^{1/2} Pr^{1/3}}{\left[1 + \left(\dfrac{0.0468}{Pr}\right)^{2/3}\right]^{1/4}}$	$Nu_x = \dfrac{0.4637 Re_x^{1/2} Pr^{1/3}}{\left[1 + \left(\dfrac{0.0207}{Pr}\right)^{2/3}\right]^{1/4}}$
Local	ξ = unheated starting length; Laminar: $Re_x < 5 \times 10^5$; $0.6 < Pr < 50$	$C_{f,x} = 0.664 Re_x^{-1/2}$	$Nu_x = Nu_{x(\text{for } \xi=0)} \left[1 - \left(\dfrac{\xi}{x}\right)^{3/4}\right]^{-1/3}$	
Local	ξ = unheated starting length; Turbulent: $5 \times 10^5 \le Re_x \le 10^7$; $0.6 \le Pr \le 60$	$C_{f,x} = 0.059 Re_x^{-1/5}$	$Nu_x = Nu_{x(\text{for } \xi=0)} \left[1 - \left(\dfrac{\xi}{x}\right)^{9/10}\right]^{-1/9}$	
Average	ξ = unheated starting length; Laminar: $Re_L < 5 \times 10^5$; p = 2; Turbulent: $5 \times 10^5 \le Re_L \le 10^7$; p = 8		$Nu_L = Nu_{L(\text{for } \xi=0)} \left(\dfrac{L}{L-\xi}\right) \left[1 - \left(\dfrac{\xi}{L}\right)^{\frac{p+1}{p+2}}\right]^{\frac{p}{p+1}}$	

Summary of Correlations for External Natural Convection

Geometry	Correlation(s)	Restrictions	Evaluation of Fluid Properties	Thermal condition
Vertical Plate	McAdams: $\mathrm{Nu}_L = 0.59\mathrm{Ra}_L^{1/4}$	$10^4 < Ra_L < 10^9$	$T_f = (T_s + T_\infty)/2$	Isothermal
	McAdams: $\mathrm{Nu}_L = 0.10\mathrm{Ra}_L^{1/3}$	$10^9 < Ra_L < 10^{13}$		
Horizontal Plate	McAdams: $\mathrm{Nu}_{L_c} = 0.54\mathrm{Ra}_{L_c}^{1/4}, L_c = \frac{A_s}{p}$	Upper surface hot or lower surface cool $10^5 \le Ra_{Lc} \le 10^7$	$T_f = (T_s + T_\infty)/2$ except for gases β at T_∞	Isothermal
	McAdams: $\mathrm{Nu}_{L_c} = 0.15\mathrm{Ra}_{L_c}^{1/3}, L_c = \frac{A_s}{p}$	Upper surface hot or lower surface cool $10^7 < Ra_{Lc} \le 10^{10}$		
	McAdams: $\mathrm{Nu}_{L_c} = 0.27\mathrm{Ra}_{L_c}^{1/4}, L_c = \frac{A_s}{p}$	Lower surface hot or Upper surface cool $10^5 \le Ra_{Lc} \le 10^{10}$		

where A_s is the surface area and p is the perimeter.

TABLE 14–4

In a binary ideal gas mixture of species *A* and *B*, the diffusion coefficient of *A* in *B* is equal to the diffusion coefficient of *B* in *A*, and both increase with temperature

T, °C	$D_{H_2O\text{-air}}$ or $D_{\text{Air-}H_2O}$ at 1 atm, in m²/s (from Eq. 14–15)
0	2.09×10^{-5}
5	2.17×10^{-5}
10	2.25×10^{-5}
15	2.33×10^{-5}
20	2.42×10^{-5}
25	2.50×10^{-5}
30	2.59×10^{-5}
35	2.68×10^{-5}
40	2.77×10^{-5}
50	2.96×10^{-5}
100	3.99×10^{-5}
150	5.18×10^{-5}

For *fully developed laminar flow* in a circular pipe, we have:

$$u(r) = 2V_{avg}\left(1 - \frac{r^2}{R^2}\right) = u_{max}\left(1 - \frac{r^2}{R^2}\right)$$

$$f = \frac{64\mu}{\rho D V_{avg}} = \frac{64}{\mathrm{Re}}$$

$$\dot{V} = V_{avg}A_c = \frac{\Delta P R^2}{8\mu L}\pi R^2 = \frac{\pi R^4 \Delta P}{8\mu L} = \frac{\pi R^4 \Delta P}{128\mu L}$$

Circular tube, laminar ($\dot{q}_s$ = constant): $\mathrm{Nu} = \frac{hD}{k} = 4.36$

Circular tube, laminar (T_s = constant): $\mathrm{Nu} = \frac{hD}{k} = 3.66$

For *developing laminar flow* in the entrance region with constant surface temperature, we have

Circular tube: $$\mathrm{Nu} = 3.66 + \frac{0.065(D/L)\,\mathrm{Re\,Pr}}{1 + 0.04[(D/L)\,\mathrm{Re\,Pr}]^{2/3}}$$

Circular tube: $$\mathrm{Nu} = 1.86\left(\frac{\mathrm{Re\,Pr}\,D}{L}\right)^{1/3}\left(\frac{\mu_b}{\mu_s}\right)^{0.14}$$

= 12 =

TABLE A–15

Properties of air at 1 atm pressure

Temp. T, °C	Density ρ, kg/m³	Specific Heat c_p, J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m²/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m²/s	Prandtl Number Pr
−150	2.866	983	0.01171	4.158×10^{-6}	8.636×10^{-6}	3.013×10^{-6}	0.7246
−100	2.038	966	0.01582	8.036×10^{-6}	1.189×10^{-5}	5.837×10^{-6}	0.7263
−50	1.582	999	0.01979	1.252×10^{-5}	1.474×10^{-5}	9.319×10^{-6}	0.7440
−40	1.514	1002	0.02057	1.356×10^{-5}	1.527×10^{-5}	1.008×10^{-5}	0.7436
−30	1.451	1004	0.02134	1.465×10^{-5}	1.579×10^{-5}	1.087×10^{-5}	0.7425
−20	1.394	1005	0.02211	1.578×10^{-5}	1.630×10^{-5}	1.169×10^{-5}	0.7408
−10	1.341	1006	0.02288	1.696×10^{-5}	1.680×10^{-5}	1.252×10^{-5}	0.7387
0	1.292	1006	0.02364	1.818×10^{-5}	1.729×10^{-5}	1.338×10^{-5}	0.7362
5	1.269	1006	0.02401	1.880×10^{-5}	1.754×10^{-5}	1.382×10^{-5}	0.7350
10	1.246	1006	0.02439	1.944×10^{-5}	1.778×10^{-5}	1.426×10^{-5}	0.7336
15	1.225	1007	0.02476	2.009×10^{-5}	1.802×10^{-5}	1.470×10^{-5}	0.7323
20	1.204	1007	0.02514	2.074×10^{-5}	1.825×10^{-5}	1.516×10^{-5}	0.7309
25	1.184	1007	0.02551	2.141×10^{-5}	1.849×10^{-5}	1.562×10^{-5}	0.7296
30	1.164	1007	0.02588	2.208×10^{-5}	1.872×10^{-5}	1.608×10^{-5}	0.7282
35	1.145	1007	0.02625	2.277×10^{-5}	1.895×10^{-5}	1.655×10^{-5}	0.7268
40	1.127	1007	0.02662	2.346×10^{-5}	1.918×10^{-5}	1.702×10^{-5}	0.7255
45	1.109	1007	0.02699	2.416×10^{-5}	1.941×10^{-5}	1.750×10^{-5}	0.7241
50	1.092	1007	0.02735	2.487×10^{-5}	1.963×10^{-5}	1.798×10^{-5}	0.7228
60	1.059	1007	0.02808	2.632×10^{-5}	2.008×10^{-5}	1.896×10^{-5}	0.7202
70	1.028	1007	0.02881	2.780×10^{-5}	2.052×10^{-5}	1.995×10^{-5}	0.7177
80	0.9994	1008	0.02953	2.931×10^{-5}	2.096×10^{-5}	2.097×10^{-5}	0.7154
90	0.9718	1008	0.03024	3.086×10^{-5}	2.139×10^{-5}	2.201×10^{-5}	0.7132
100	0.9458	1009	0.03095	3.243×10^{-5}	2.181×10^{-5}	2.306×10^{-5}	0.7111
120	0.8977	1011	0.03235	3.565×10^{-5}	2.264×10^{-5}	2.522×10^{-5}	0.7073
140	0.8542	1013	0.03374	3.898×10^{-5}	2.345×10^{-5}	2.745×10^{-5}	0.7041
160	0.8148	1016	0.03511	4.241×10^{-5}	2.420×10^{-5}	2.975×10^{-5}	0.7014
180	0.7788	1019	0.03646	4.593×10^{-5}	2.504×10^{-5}	3.212×10^{-5}	0.6992
200	0.7459	1023	0.03779	4.954×10^{-5}	2.577×10^{-5}	3.455×10^{-5}	0.6974
250	0.6746	1033	0.04104	5.890×10^{-5}	2.760×10^{-5}	4.091×10^{-5}	0.6946
300	0.6158	1044	0.04418	6.871×10^{-5}	2.934×10^{-5}	4.765×10^{-5}	0.6935
350	0.5664	1056	0.04721	7.892×10^{-5}	3.101×10^{-5}	5.475×10^{-5}	0.6937
400	0.5243	1069	0.05015	8.951×10^{-5}	3.261×10^{-5}	6.219×10^{-5}	0.6948
450	0.4880	1081	0.05298	1.004×10^{-4}	3.415×10^{-5}	6.997×10^{-5}	0.6965
500	0.4565	1093	0.05572	1.117×10^{-4}	3.563×10^{-5}	7.806×10^{-5}	0.6986
600	0.4042	1115	0.06093	1.352×10^{-4}	3.846×10^{-5}	9.515×10^{-5}	0.7037
700	0.3627	1135	0.06581	1.598×10^{-4}	4.111×10^{-5}	1.133×10^{-4}	0.7092
800	0.3289	1153	0.07037	1.855×10^{-4}	4.362×10^{-5}	1.326×10^{-4}	0.7149
900	0.3008	1169	0.07465	2.122×10^{-4}	4.600×10^{-5}	1.529×10^{-4}	0.7206
1000	0.2772	1184	0.07868	2.398×10^{-4}	4.826×10^{-5}	1.741×10^{-4}	0.7260
1500	0.1990	1234	0.09599	3.908×10^{-4}	5.817×10^{-5}	2.922×10^{-4}	0.7478
2000	0.1553	1264	0.11113	5.664×10^{-4}	6.630×10^{-5}	4.270×10^{-4}	0.7539

Note: For ideal gases, the properties c_p, k, μ, and Pr are independent of pressure. The properties ρ, ν, and α at a pressure P (in atm) other than 1 atm are determined by multiplying the values of ρ at the given temperature by P and by dividing ν and α by P.

Source: Data generated from the EES software developed by S. A. Klein and F. L. Alvarado. Original sources: Keenan, Chao, Keyes, Gas Tables, Wiley, 1984; and Thermophysical Properties of Matter. Vol. 3: Thermal Conductivity, Y. S. Touloukian, P. E. Liley, S. C. Saxena, Vol. 11: Viscosity, Y. S. Touloukian, S. C. Saxena, and P. Hestermans, IFI/Plenun, NY, 1970, ISBN 0-306067020-8.

TABLE A-9

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg·K Liquid	Vapor	Thermal Conductivity k, W/m·K Liquid	Vapor	Dynamic Viscosity μ, kg/m·s Liquid	Vapor	Prandtl Number Pr Liquid	Vapor	Volume Expansion Coefficient β, 1/K Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-3}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-3}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-3}	0.934×10^{-5}	11.2	1.00	0.015×10^{-3}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-3}	0.946×10^{-5}	9.45	1.00	0.733×10^{-3}
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138×10^{-3}	0.959×10^{-5}	8.09	1.00	0.138×10^{-3}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-3}	0.973×10^{-5}	7.01	1.00	0.195×10^{-3}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-3}	0.987×10^{-5}	6.14	1.00	0.247×10^{-3}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-3}	1.001×10^{-5}	5.42	1.00	0.294×10^{-3}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-3}	1.016×10^{-5}	4.83	1.00	0.337×10^{-3}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-3}	1.031×10^{-5}	4.32	1.00	0.377×10^{-3}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-3}	1.046×10^{-5}	3.91	1.00	0.415×10^{-3}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-3}	1.062×10^{-5}	3.55	1.00	0.451×10^{-3}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-3}	1.077×10^{-5}	3.25	1.00	0.484×10^{-3}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-3}	1.093×10^{-5}	2.99	1.00	0.517×10^{-3}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-3}	1.110×10^{-5}	2.75	1.00	0.548×10^{-3}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-3}	1.126×10^{-5}	2.55	1.00	0.578×10^{-3}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-3}	1.142×10^{-5}	2.38	1.00	0.607×10^{-3}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-3}	1.159×10^{-5}	2.22	1.00	0.653×10^{-3}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-3}	1.176×10^{-5}	2.08	1.00	0.670×10^{-3}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-3}	1.193×10^{-5}	1.96	1.00	0.702×10^{-3}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-3}	1.210×10^{-5}	1.85	1.00	0.716×10^{-3}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-3}	1.227×10^{-5}	1.75	1.00	0.750×10^{-3}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-3}	1.261×10^{-5}	1.58	1.00	0.798×10^{-3}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-3}	1.296×10^{-5}	1.44	1.00	0.858×10^{-3}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-3}	1.330×10^{-5}	1.33	1.01	0.913×10^{-3}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-3}	1.365×10^{-5}	1.24	1.02	0.970×10^{-3}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-3}	1.399×10^{-5}	1.16	1.02	1.025×10^{-3}
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170×10^{-3}	1.434×10^{-5}	1.09	1.05	1.145×10^{-3}
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160×10^{-3}	1.468×10^{-5}	1.03	1.05	1.178×10^{-3}
180	1,002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150×10^{-3}	1.502×10^{-5}	0.983	1.07	1.210×10^{-3}
190	1,254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142×10^{-3}	1.537×10^{-5}	0.947	1.09	1.280×10^{-3}
200	1,553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134×10^{-3}	1.571×10^{-5}	0.910	1.11	1.350×10^{-3}
220	2,318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122×10^{-3}	1.641×10^{-5}	0.865	1.15	1.520×10^{-3}
240	3,344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111×10^{-3}	1.712×10^{-5}	0.836	1.24	1.720×10^{-3}
260	4,688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102×10^{-3}	1.788×10^{-5}	0.832	1.35	2.000×10^{-3}
280	6,412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094×10^{-3}	1.870×10^{-5}	0.854	1.49	2.380×10^{-3}
300	8,581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086×10^{-3}	1.965×10^{-5}	0.902	1.69	2.950×10^{-3}
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078×10^{-3}	2.084×10^{-5}	1.00	1.97	
340	14,586	610.5	92.62	1028	8240	11,870	0.469	0.110	0.070×10^{-3}	2.255×10^{-5}	1.23	2.43	
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060×10^{-3}	2.571×10^{-5}	2.06	3.73	
374.14	22,090	317.0	317.0	0	—	—	—	—	0.043×10^{-3}	4.313×10^{-5}			

Note 1: Kinematic viscosity ν and thermal diffusivity α can be calculated from their definitions, $\nu = \mu/\rho$ and $\alpha = k/\rho c_p = \nu/\text{Pr}$. The temperatures 0.01°C, 100°C, and 374.14°C are the triple-, boiling-, and critical-point temperatures of water, respectively. The properties listed above (except the vapor density) can be used at any pressure with negligible error except at temperatures near the critical-point value.

Note 2: The unit kJ/kg·°C for specific heat is equivalent to kJ/kg·K, and the unit W/m·°C for thermal conductivity is equivalent to W/m·K.

Source: Viscosity and thermal conductivity data are from J. V. Sengers and J. T. R. Watson, *Journal of Physical and Chemical Reference Data* 15 (1986), pp. 1291–1322. Other data are obtained from various sources or calculated.

L-3/T-1/ME Date : 11/09/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **ME 349** (Mechanics of Machinery)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A rack may be regarded as a wheel of infinite radius; the teeth are straight sided and are normal to the line of contact. To avoid interference in rack and pinion meshing determine the minimum number of teeth in pinion for a standard addendum with pressure angle of $14\frac{1}{2}$°. Draw necessary sketch for our answer **(17)**

(b) A compound epicyclic gear is shown in Figure for Q.1(b). The shaft P in driven at 3000 rev/min while the annulas A_2 is driven at 1000 rev/min in the opposite direction. The number of teeth in the gears are S_1, 16: S_2, 24: A_1, 60; A_2, 90. Determine the speed and direction of rotation of shaft Q. **(18)**

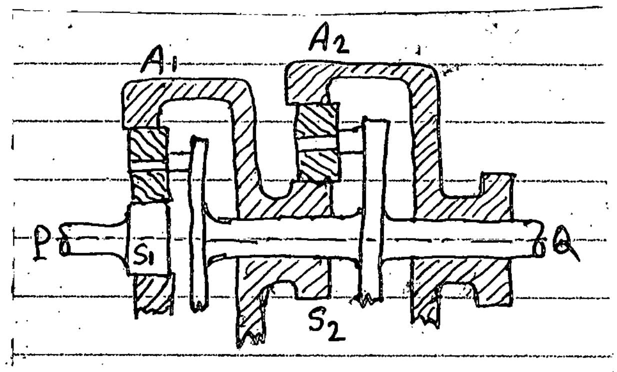


Figure for Q.1(b)

2. (a) Deduce a expression for the whirling speed of a light shaft which carries a single disc at a given point along its length. The shaft of a small turbine with a single disc in found to have a static deflection of 0.355 mm. Calculate the whirling speed and find what percentage change in the diameter of the shaft will be required in order to raise the whirling speed to 2100 rev/min. Assume, E = 200 GN/m^2. **(17)**

(b) A turbine rotor is connected to a pinion B by a shaft AB of uniform diameter and the pinion meshes with a gear wheel C. The moments of inertia of A, B, and C are in the ratio of 15:1:36 and the gear ratio is 5:1. If the system is in torsional vibration find the position of the node along the shaft AB. **(18)**

The moments of inertia of A is 140 kg-m^2 and the torsional stiffness of the shaft AB is 5.5 kN-m per degree of twist. Find the frequency of the torsional vibration of the system. Take G = 80 GPa.

3. (a) Write down the differential equation and obtain its solution for the free damped vibration of a body of mass m, if the restoring force is S per unit displacement from the neutral position and the damping force is C per unit velocity. **(17)**

Contd P/2

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Contd ... Q. No. 3(a)

In such a system a mass of 25 kg is suspended from a helical spring of stiffness 15 kN/m, the motion being controlled by a dash-pot such that the amplitude of the vibration decreases to one-fifth of its original value after 2 complete vibrations.

Find (i) the value of the damping force,

(ii) The frequency of the vibration.

(b) A small vertical engine is supported on a steel joist at mid-span. The mass of the engine including an allowance for the mass of the joist is 100 kg and the static deflection of the joist is 4 mm. The stroke of the engine is 100 mm and the mass of the reciprocating parts is 1 kg. If the reciprocating parts are assumed to have simple harmonic motion, find the amplitude of the forced vertical vibration when the speed of rotation of the engine crank is 800 rev/min. **(18)**

4. (a) A motor vehicle of all-up mass 900 kg has a track of 1.5 m and the center of gravity is 0.38 m above ground level. The four road wheels have a total moment of inertia of 5 kg-m^2 and a rolling radius of 0.3 m. The vehicle is travelling at a speed of 45 m/s in a circular path of radius 180 m. **(17)**

Determine (i) The total vertical component of the reaction on the two outer wheels, if the track is not banked;

(ii) The angle of banking necessary for there to be no tendency for the vehicle to sideslip.

(b) In a viscous damped vibrating system the suspended body has a mass of 70 kg and the stiffness of the suspension is 9 kN/m of deflection. The damping force is proportional to velocity and is equal to 300 N at a velocity of 1 m/s. An external force of magnitude 180 *cos wt* N is applied directly to the suspended body, *w* being variable. **(18)**

Determine, justifying any equation used, the maximum possible value of the vibration amplitude, the frequency at which if occurs, and the phase angle difference between the applied force and the motion.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. A cam is to be designed for a roller edge follower with the following data. **(35)**

(a) Cam lift is 20 mm during 60° of cam rotation with constant acceleration and retardation.

(b) Dwell the next 90°

(c) During the next 45° of cam rotation, the follower returns to its original position with SHM.

Contd P/3

ME 349

Contd ... Q. No. 5

(d) Dwell during the remaining rotation.

(e) The diameter of the roller of the follower is 10 mm and its direction of motion is offset 10 mm.

The radius of the base circle is 35 mm. Draw the cam profile.

6. (a) A three cylinder radial engine driven by a common crank has the cylinders spaced at 120°. The stroke is 125 mm, length of the connecting rod is 225 mm. and the mass of the reciprocating parts per cylinder is 2 kg. Calculate the primary and secondary forces at crank shaft speed of 1000 rpm. **(15)**

(b) The reciprocating masses of the first three cylinders of a four cylinder engine are 4, 6 and 7 tons, respectively. The centre lines of the three cylinders are 5.2 m, 3.2 m and 1.2 m from the fourth cylinder. If the cranks for all the cylinders are equal, determine the reciprocating mass of the fourth cylinder and the angular position of the cranks such that the system is completely balanced for the primary force and couple. If the cranks are 0.8 m long, the connecting rods 3.8 m, and the speed of the engine 75 rpm, find the maximum unbalanced secondary force and the crank angle at which it occurs. **(20)**

7. (a)The torque exerted on the shaft of a two stroke engine is given by the equation **(17)**

$$T(N\text{-}m) = 14500 + 2300 \sin 2\theta - 1900 \cos 2\theta$$

where θ is the crank angle displacement from the inner deed centre. Assuming the resisting torque to be constant, determine (i) the power of the engine when the speed is 150 r.p.m. (ii) The moment of inertia of the flywheel if the speed variation is not to exceed ± 0.5% of the mean speed, and (iii) The angular acceleration of the flywheel when the crank has turned through 30° from the inner dead centre.

(b) A punching press pierces 20 holes per minute in a plate using 6 kN-m of energy per hole during each revolution. Each piercing takes 15 percent of the time needed to make one revolution. A cast iron fly wheel used with the punching machine is driven by a constant torque electric motor. The fly wheel rotates at a mean speed of 250 rpm and the fluctuation of speed is not to exceed ± 2 percent of the mean speed. Find (i) power of the electric motor. (ii) mass of the fly wheel and (iii) cross-sectional dimension of the rim when the width is four times of its thickness. Assume hoop-stress of cast iron 6 MPa and density of cast iron 7500 kg/m^3. **(18)**

8. (a) Two shafts whose centres are 1 m apart are connected by a V-belt drive. The driving pulley is supplied with 150 kw and has an effective diameter of 325 mm. It runs at 1250 rpm. while the driven pulley runs at 375 rpm. The angle of groove on the pulley is 40°. The permissible tension in 400 mm^2 cross-section area belt is 2.5 MPa. The density of the

Contd P/4

ME 349

Contd ... Q. No. 8(a)

belt is 1100 kg/m^3. The coefficient of friction between the belt and pulley is 0.28. Estimate the number of ropes required.

(b) A differential band brake is shown in Fig. for. Q. No. 8(b). The diameter of the drum is 800 mm. The coefficient of friction between the band and the drum is 0.3. When a force of 600 N is applied at the free and of the lever, find for clockwise and anti-clockwise rotation of the drum- (i) the maximum and minimum forces in the band, and (ii) the torque which can be applied by the brake. **(17)**

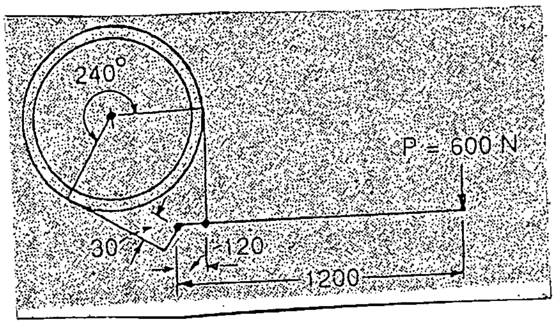

Fig. for Q. No. 8(b)

L-3/T-1/ME **Date : 17/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **ME 361** (Instrumentation and Measurement)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Assume any data if necessary. Symbols used have their usual meaning.

1. (a) What are the 'open-loop' characteristics of an 'op-amp'? Draw typical connection of an 'op-amp' for its use as **(20)**

(i) Non-inverting amplifier

(ii) Inverting amplifier

Also derive input-output relationship for the above circuits using two 'golden' rules of op-amp.

(b) Calculate the input voltage V_1 if the final output voltage V_0 is 12 V. **(7)**

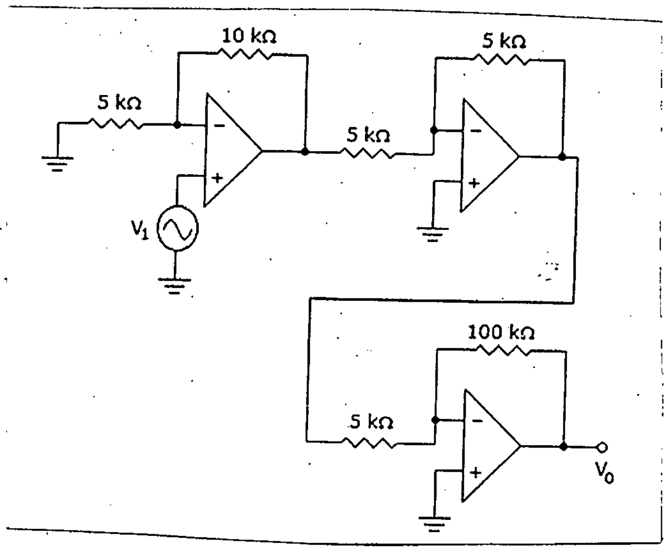

Fig. for Q. No. 1(b)

(c) Draw an active circuit that provides a constant output from dc up to a cutoff frequency and passes no signal above that frequency and derive its input- output relationship. **(8)**

2. (a) Write a Boolean expression for the following truth table using 'sum of product (sop)' and simplify the expression: **(13)**

Inputs			Outputs
A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Contd P/2

ME 361

Contd... Q. No. 2

(b) Simplify the logic circuit shown in Fig. for Q. No. 2(b) and draw the simplified circuit. **(15)**

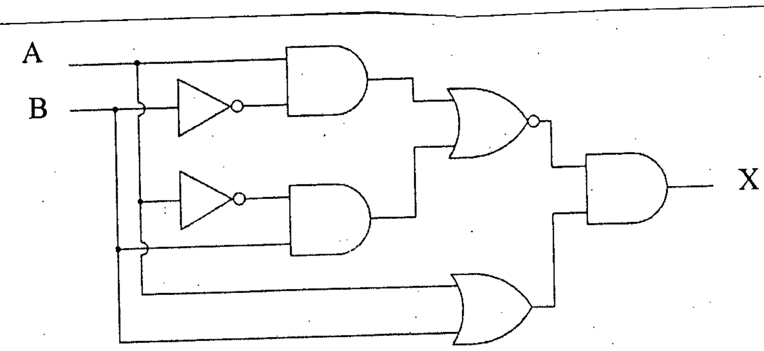

Fig. for Q. No. 2(b)

(c) One digital temperature data recorder is to be designed to record a value between 0°C to 400°C. It has to be capable of detecting at least 0.5°C change in temperature data. Determine the minimum bit-size of the ADC. **(7)**

3. (a) Classify data transmission modes used in communication systems. **(5)**

(b) Distinguish between (i) Parallel and serial data communication and (ii) Synchronous and Asynchronous serial communication. **(10)**

(c) What is Nyquist frequency? Mention its importance in sampling data. **(5)**

(d) Derive the expression for the gage factor of a strain gage. **(15)**

4. (a) Describe the working principle of piezoelectric and Hall effect sensors. **(6)**

(b) With a neat sketch illustrate the working mechanism of an LVDT type transducer. **(10)**

(c) What is a Dynamometer? Describe in brief how different types of dynamometers are used to measure the mechanical power of a rotating machine. **(10)**

(d) Draw a schematic of a seismic instrument and explain in brief how it measures vibration. **(9)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) Explain the components of a general measurement system. Give a suitable example. **(10)**

(b) Explain different types of responses from measuring instruments. Mention some of the responses of a first order measurement system. **(10)**

Contd P/3

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Contd... Q. No. 5

(c) A thermometer having a time constant of 5 second is initially at 25°C and suddenly exposed to an oil bath maintained at 200°C. Estimate the rise time. If the thermometer is subjected to an environment where actual temperature is varying in harmonic nature with amplitude of 50°C at 0.01 Hz frequency. Estimate time and phase lag of the thermometer and amplitude attenuation. **(15)**

6. (a) Briefly explain the working principle of 'Mcleod Guage'. **(10)**

   (b) Briefly explain the different types of errors in measuring systems. Explain how to address random errors. **(10)**

   (c) Distinguish between accuracy and precision. If resistance of a wire is given by **(15)**

$$R = \in \frac{L}{A}$$

where all the symbols have their usual meanings. It is given that

$$\in = 100\ \Omega.\text{m}$$

$$L = 10 \pm 0.1\ \text{cm}$$

$$A = 1.0\ \text{cm}^2 \pm 2\%$$

Estimate the uncertainty of resistance.

7. (a) Briefly explain the working principle and the key characteristics of Bimetallic strip thermometer. **(10)**

   (b) Briefly explain the working principle of infra-red thermometer. **(10)**

   (c) Make brief comparison between RTD, thermocouple, thermistor and IC based temperature measurement systems. **(15)**

8. (a) Briefly explain the 'home water meter'. **(10)**

   (b) Explain the working principle of a measuring system suitable for slurry water flow rate measurement. **(10)**

   (c) Briefly explain the working principle and the key characteristics of a Rotameter. **(15)**

L-3/T-1/ME **Date: 23/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

Sub: **IPE 331** (Production Processes)

Full Marks: 280 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What are some of the materials used in making casting patterns? What features should be considered when selecting a pattern material? Explain briefly. **(12)**

(b) With the help of suitable sketches discuss the following: **(12)**

(i) Pressure die casting

(ii) Centrifugal casting

(c) Describe briefly the investment casting with necessary sketch. What are the advantages and limitations of investment casting in comparison with sand mold casting? **(12)**

(d) With the help of suitable diagram, describe the various elements of gating system. What is the function of chills? **(10⅔)**

2. (a) Classify the types of chips and also state under what conditions of machining those different types of chips form. What are meant by orthogonal cutting and oblique cutting? **(12)**

(b) Define chip reduction coefficient. Derive the expression for shear angle (β) in orthogonal cutting in terms of rake angle and chip reduction coefficient. **(12)**

(c) Draw a Merchant's circle diagram (MCD) and visualize in it the various cutting force components that arise during orthogonal turning. Derive, with the help of MCD, simple expression for (i) P_s and P_n (ii) F and N. **(12)**

(d) While turning a metal rod of diameter 150 mm at speed of 560 rpm, feed of 0.32 mm/rev and 4.0 mm depth of cut by a tool having tool rake angle - 12° and principal cutting edge angle 60°, it was noted that P_z = 1000 N, P_y = 200 N and chip thickness, a_2 = 0.80 mm. Determine co-efficient of friction and dynamic yield shear strength. **(10⅔)**

3. (a) Based on the composition of the joint, the joining processes can be classified as autogenous, homogeneous and heterogeneous type. Explain what do you understand by these? **(12)**

Contd P/2

IPE 331/ME

Contd... Q. No. 3

(b) With the help of neat sketches, describe briefly the principles of operation and give one suitable industrial application of the following welding processes: **(12)**

(i) Flash Welding

(ii) Thermit Welding

(c) Explain the similarities and differences between Electron-beam and Laser-beam welding. Give some typical applications for each. **(12)**

(d) Enumerate common defects encountered with welding products and suggest methods to counter these defects. Identify the factors that affect weldability. **(10⅔)**

4. (a) Explain why a casting may have a slightly different shape than the pattern used to make the mold. Explain the difference in the importance of drafts in green sand casting and die mold casting. **(12)**

(b) In an orthogonal cutting tool, what are the important angles that are to be maintained? For each of the angle explain its influence on the machining performance. **(12)**

(c) What mechanisms of wear do cutting tools undergo during their use in machining? What properties should a cutting tool materials essentially possess and why? **(12)**

(d) Discuss the factors that influence weld quality. Why are residual stresses important in welded components? Describe the methods used for relieving or reducing residual stresses in welds. **(10⅔)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Distinguish between generating and forming when machining workpiece geometries. Give two examples of machining operations in which generating and forming are combined to create workpiece geometry. **(11⅔)**

(b) In which taper turning method is the cross slide first made free from the lead screw by removing the binder screw? Explain with neat diagram. **(10)**

(c) How does a boring operation differ from a turning operation? **(10)**

(d) A 52 mm diameter gray cast iron (specific cutting energy (unit power), K = 915 N/mm^2) workpiece is rough turned with an uncoated carbide tool (maximum depth of cut 4.4 mm). The feed for the tool is 0.4 mm per revolution (mm/rev), the depth of cut is 4.2 mm, and the recommended cutting speed is 75 m/min. **(15)**

Calculate:

Contd P/3

IPE 331/ME

Contd... Q. No. 5(d)

(i) The material removal rate (MRR or volumetric rate of machining) in mm^3/min.

(ii) Machining power required by the Spindle.

(iii) Spindle revolution per minute.

(iv) Spindle torque using cutting power.

(v) The machining time if the axial length of the outer diameter cut is 152.5 mm. Assume the over travel of the tool beyond the length of the job is 2.5 mm.

6. (a) Differentiate peripheral milling from face milling? For peripheral milling (*i.e.* Slab milling) in figure Q. 6(a), if depth of cut, d is one-fourth of cutter diameter, D then prove that the approach distance, $A = \frac{\sqrt{3}}{4} D$. **(20⅔)**

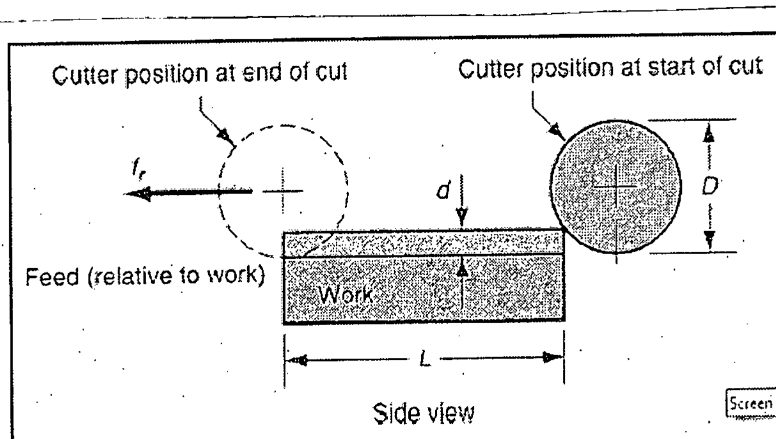

Figure Q. 6(a). Peripheral milling operation

(b) How do shaping and planning differ? Draw common shaping and planning geometry. **(12)**

(c) A drilling operation is to be performed with a 12.7 mm diameter twist drill in a steel workpiece. The hole is a blind hole at a depth of 60 mm and the point angle is 118°. The cutting speed is 25 m/min and the feed is 0.30 mm/rev. **(14)**

Determine:

(i) The cutting time to complete the drilling operation, and

(ii) Metal removal rate during the operation, after the drill bit reaches full diameter.

7. (a) Classify forging operations by the degree to which the work is constrained in the die. Why is 'flash' desirable in impression-die forging? **(11⅔)**

(b) Discuss different types of defects commonly observed in an extruded product. **(10)**

Contd P/4

IPE 331/ME

Contd... Q. No. 7

(c) In a surface grinding operation performed on hardened plain carbon steel, the grinding wheel has a diameter = 200 mm and width = 25 mm. The wheel rotates at 2400 rev/min, with a depth of cut (infeed) = 0.05 mm/pass and a crossfeed = 3.50 mm. The reciprocating speed of the work is 6 m/min, and the operation is performed dry. **(25)**

Determine:

(i) Length of contact between the wheel and the work.

(ii) Volume rate of metal removed.

(iii) If there are 64 active grits/cm^2 of wheel surface, estimate the number of chips formed per unit time.

(iv) What is the average volume per chip?

(v) If the tangential cutting force on the work = 25 N, compute the specific energy in this operation.

8. (a) In rolling of steel, what are the differences between a bloom, a slab, and a billet? **(10)**

(b) What are the cost components in a machining operation? Derive an expression for the cutting speed that minimizes the total cost per piece. **(20⅔)**

(c) With the help of suitable sketches describe the following operations: **(16)**

(i) Flanging

(ii) Dimpling

(iii) Beading

(iv) Explosive forming process.

L-3/T-1/ME Date: 29/09/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

Sub: **ME 321** (Fluid Mechanics I)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Discuss the term 'rigid body motion' in a fluid system. **(5)**

(b) Show that the pressure gradient at a point in a fluid body depends on the acceleration at the point. Hence, establish a general equation of pressure variation in a fluid body. **(15)**

(c) The 2.4 m high container contains 2.0 m deep water. It has an air vent on its top as shown in Fig. Q1.c. Determine the pressure at points A, B, and C if $a_x = 20$ m/s^2 and $a_z = 10$ m/s^2. **(15)**

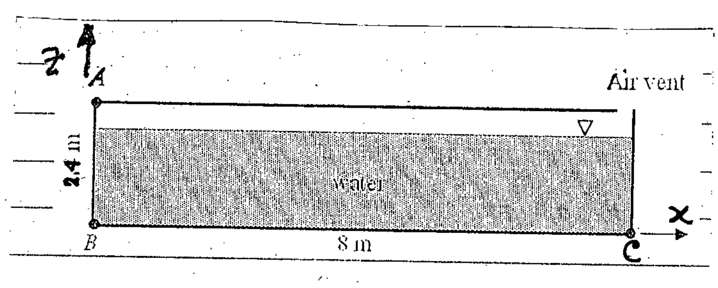

Fig. Q1.c

2. (a) Discuss why the concept of continuum is important in fluid mechanics. **(5)**

(b) Gate AB in Fig. 2.b is 4 m wide into the paper and opens to let fresh water out when the ocean tide is dropping. The hinge at A is 1 m above the fresh water level. At which ocean level h will the gate first open? Neglect the gate weight. **(16)**

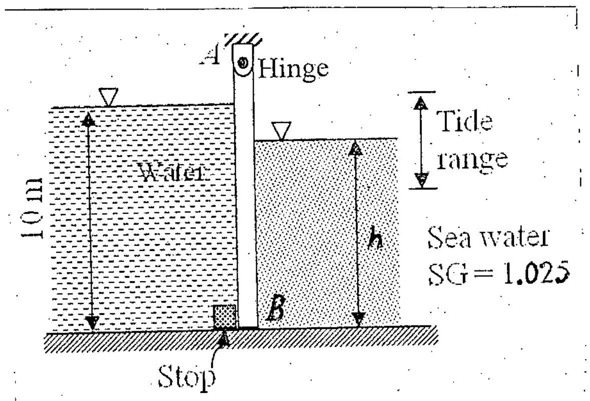

Fig Q2.b

Contd P/2

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Contd... Q. No. 2

(c) Consider the cylindrical log of diameter 3 m and length 6 m shown in Fig. 2.c. If the fluid on the left has a specific gravity of 1.6 and on the right has a specific gravity of 0.8, find the magnitude and direction of the resultant force. **(14)**

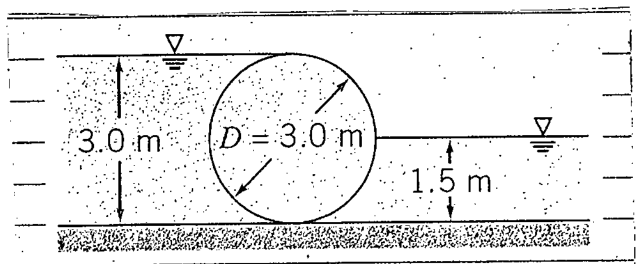

Fig Q2.c

3. (a) Discuss the condition of stability of a floating body in terms of metacentric height. **(5)**

(b) Consider a homogeneous right circular cylinder of length L, radius R, and specific gravity SG = 0.5, floating in water (SG = 1). Determine the relation between L and R that will ensure stability of the floating cylinder if **(18)**

(i) its axis is horizontal, (ii) its axis is vertical

(c) The velocity components in a steady, incompressible, two dimensional flow field are: $u = 2y$ and $v = 4x$ **(12)**

Determine the corresponding stream function and plot the streamlines for $\psi = 0$ and $\psi = 1$. Indicate the direction of flow along the streamlines.

4. (a) What is doublet? Determine the stream function for doublet. **(10)**

(b) What is free vortex? Express the strength of a free vortex in terms of circulation. **(10)**

(c) Deduce the appropriate stream function and velocity potential function for studying the flow around a circular cylinder. Hence show that the drag as well as the lift is zero. Is this prediction by the potential flow theory justified? Why or why not? **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) How can you differentiate between "system approach" and "control volume approach" for the analysis of engineering problems? **(15)**

Derive the generalized time rate form of "Reynolds Transport Theorem" which relates the above two approaches in context of fluid dynamics.

(b) Briefly explain the concept of material derivative. Deduce an expression of material acceleration for three-dimensional Cartesian coordinate system (x, y, z). **(12)**

(c) An incompressible, inviscid fluid flows steadily past a tennis ball of radius R, as shown in Fig. for Q. No. 5(c). The fluid velocity along the streamline A-B is given by **(8)**

$$\vec{V} = V_0\left(1 + \frac{R^3}{x^3}\right)\hat{i} \text{ (m/s)}$$

where V_0 is the upstream velocity far ahead of the tennis ball.

Determine the acceleration experienced by fluid particles as they follow along this streamline.

Contd P/3

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Contd... Q. No. 5(c)

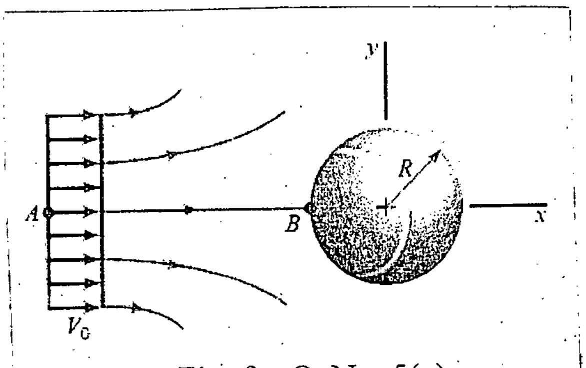

Fig. for Q. No. 5(c)

6. (a) Derive the Euler differential formula using the integral relations of continuity and linear momentum for a control volume in context of fluid dynamics. What are the physical restrictions of this differential formula? **(15)**

(b) The measured water pressure at the inlet and exit of a pump is shown in Fig. for Q. No. 6(b). If the flow rate is 360 m^3/hr, determine the hydraulic power that the pump supplies to the water. Assume a head loss of 2.0 m in the flow system. **(10)**

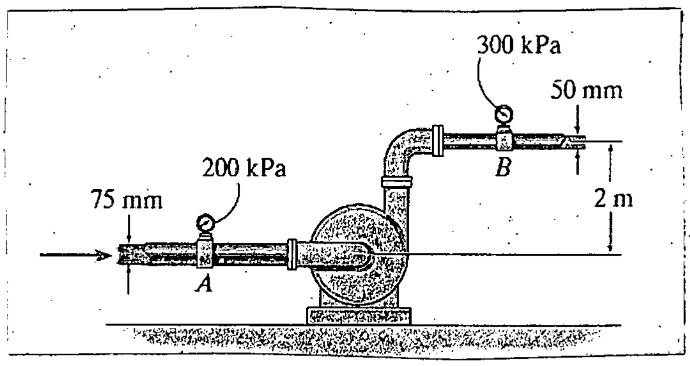

Fig. for Q. No. 6(b)

(c) A 1.0 m diameter cylindrical water tank whose top is open to atmosphere as shown in Fig. for Q. No. 6(c) is initially (t = 0) filled with water at a height, h_1 = 2.5 m. Now, the discharge plug is pulled out, and a water jet streams out with diameter, D_2 = 50 mm. The average velocity of the jet is given by: **(10)**

$$V_{jet} = \sqrt{2gh} \text{ (m/s)}$$

where h is the height of water above the plug and $g = 9.8$ m/s^2. Determine how long the water jet will be streaming out from the tank if the discharge plug is at a height of h_2 = 1.5 m.

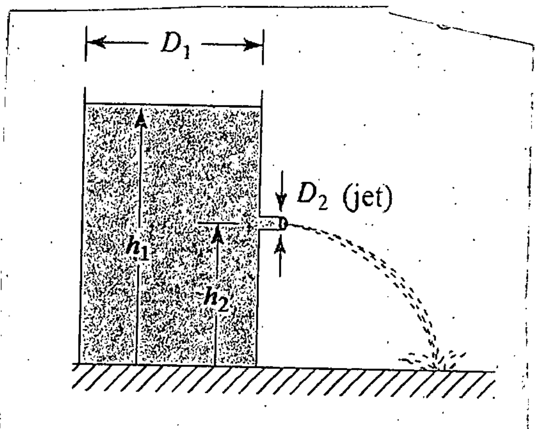

Fig. for Q. No. 6(c)

7. (a) The mechanical power output from a wind turbine can be theoretically predicted using momentum principle. Two streamlines and the associated control volume are shown in Fig. for Q. No. 7(a) to implement this principle. Show that the mechanical efficiency of such turbine is limited by $\frac{16}{27}$. **(15)**

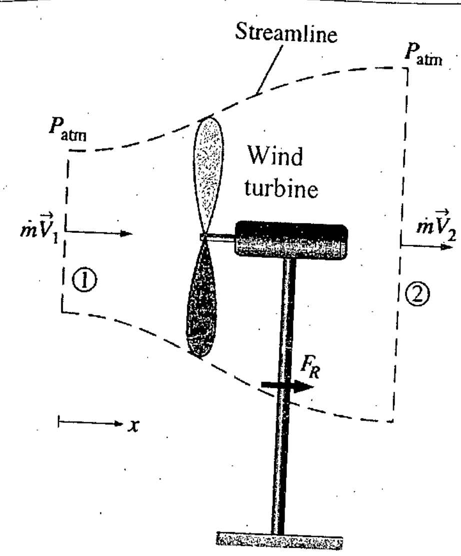

Fig. for Q. No. 7(a)

(b) Water flows through the 100 mm diameter pipe with a velocity of 5 m/s as shown in Fig. for Q. No. 7(b). If the pressures in the pipe at A and B are 80 kPa, and 70 kPa, respectively, determine the x- and y-components of force the flow exerts on the elbow. The flow occurs in the horizontal plane. **(10)**

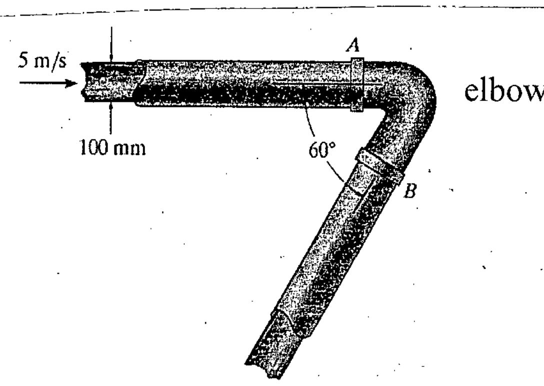

Fig. for Q. No. 7(b)

(c) The free stream air velocity is to be measured in a wind tunnel. Suggest a suitable equipment for this measurement. Also explain the working principle of such equipment with necessary schematic diagram (s). **(10)**

Contd P/5

ME 321

8. (a) Briefly explain the importance of differential analysis of fluid dynamics. Derive the differential form of continuity equation and hence show that for steady incompressible flow, it can be expressed by **(15)**

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

where $\vec{V} = (u, v, w)$ and $\nabla = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right)$.

(b) Determine the pressure difference (in kPa) between points B and A for the arrangement and readings of the inclined manometer shown in Fig. for Q. No. 8(b). **(10)**

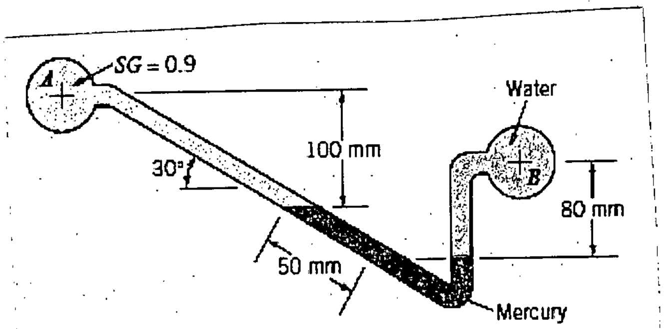

Fig. for Q. No. 8(b)

(c) The read-wire head for a computer hard disk has a surface area of 0.04 mm^2. The head is held 0.04 μm above the disk, which is rotating at a constant rate of 1800 rpm. Determine the torque T that must be applied to the disk to overcome the frictional shear resistance of the air between the head and the disk. Assume the velocity profile is linear and $\mu_{air} = 1.8 \times 10^{-5}$ Pa.s. **(10)**

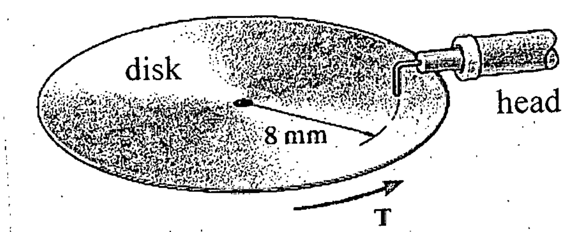

Fig. for Q. 8(c)
