L-3/T-1/ME **Date: 02/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

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.

1. (a) Explain thermal diffusivity and its role in the analysis of steady heat conduction. **(5)**

(b) Name the performance parameters of fin used in heat transfer. How are those related? Enlist some design considerations of fins. **(10)**

(c) A cylindrical nuclear fuel rod of 15 mm - diameter is encased a concentric hollow ceramic cylinder with inner diameter of 35 mm and outer diameter of 110 mm. This created an air gap between the rod and the hollow cylinder with a convection heat transfer coefficient of 10 $\frac{W}{m^2k}$. The ceramic cylinder has a thermal conductivity of $0.07\frac{W}{mk}$ and its outer surface maintains a constant temperature of 30°C as shown in Fig. 1. If the fuel rod generates heat at a rate of 1 m $W/_{m^3}$, determine the temperature (T_1) at the surface of the fuel rod. **(20)**

2. (a) Condensate film thickness is given by- **(20)**

$$\delta(x)=\left[\frac{4m_l k_l (T_{sat}-T_s)x}{gp_l(p_l-p_v)h_{fg}*}\right]^{1/4}$$

where symbols have their usual meaning and $h_{fg}* = h_{fg} + 0.68\ c_{pl}\ (T_{sat} - T_s)$. Draw a schematic diagram of the condensation system and enlist the assumptions.

Using the above relation, derive an expression of average heat transfer coefficient.

(b) Steam is being condensed at 60 °C by a 15-m-long horizontal copper tube of diameter tube of diameter 25 mm. The tube surface is maintained at 40°C. Determine the condensation rate during film condensation. Discuss the result in relation with dropwise condensation. **(15)**

3. (a) Illustrate spectral emissive power of backbody radiation and mention salient points. Also deduce the Wein's Displacement law from this. **(20)**

(b) A radiometer is employed to monitor the temperature of manufactured parts (A_1 = 10 cm^2) on a conveyor (Fig.2). **(15)**

Contd P/2

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The radiometer is placed at a distance of 1m from the manufactured parts. When a part-moves to the position normal to the radiometer, the sensor measures the radiation emitted from the part. In order to prevent thermal burn on people handling the manufactured parts at the end of the conveyor, the temperature of the parts should be below 45°C. An array of spray heads is programmed to discharge mist to cool the parts when the radiometer detects a temperature of 45° or higher on a part. If the manufactured parts can be approximated as blackbody, determine the irradiation on the radiometer that should trigger the spray heads to release cooling mist when the temperature is not below 45°C.

4. (a) Find the fraction of radiation leaving surface-1 and intercepted by surface -2 as shown in Fig. 3. Given that the emissivity and the temperature are 0.8 and 1000 k for surface-1 and those for surface-2 are 0.6 and 500 k, respectively, calculate the net radiative heat transfer. **(15)**

(b) A furnace is shaped like a long equilateral triangular duct, as shown in Fig. 4. The width of each side is 1m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600K. The heated left-side surface closely approximates a blackbody at 1000K. 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)**

SECTION – B

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

5. (a) With suitable example, differentiate "Lumped System" and "Distributed System" from heat conduction viewpoint. **(17)**

Obtain a relation for the time required for a lumped system to reach the average temperature, $\frac{1}{2}(T_i + T_\alpha)$, where T_i is the initial temperature of the lumped system and T_α is the temperature of environment.

(b) Consider a steel pipeline (AISI 1010: p = 7832 kg/m^3, c_p = 434 J/kg.K, k = 63.9 W/m.K, α = 18.8× 10^{-6} m^2/s.) that is 1 m in diameter and has a wall thickness of 40 mm. The pipe is heavily insulated on the outside and before the initiation of flow, the walls of the pipe are at a uniform temperature of 20°C. With the initiation of flow, hot oil at 60°C is pumped through the pipe, creating a convective condition corresponding to h = 500 W/m^2.K at the inner surface of the pipe. **(18)**

Contd P/3

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(i) What are the appropriate Biot number and Fourier number 8 min after the initiation of flow?

(ii) At t = 8 min, what is the temperature of the exterior pipe surface covered by the insulation?

(iii) What is the instantaneous heat flux to the pipe from the oil at t = 8 min.

Use the "First Term Approximate" method for your calculation.

6. (a) An 8-cm-diameter potato [k = 0.6 W/m.K, p = 1100 kg/m^3, and c_p = 3900 J/kg.K, α = 1.4×10^{-7} m^2/s] that is initially at a uniform temperature of 25°C is baked in an oven at 170°C until a temperature sensor inserted to the center of the potato indicates a reading of 70°C. The potato is then taken out of the oven and wrapped in thick towels so that almost no heat is lost from the baked potato. Assuming the heat transfer coefficient in the oven to be 25 W/m^2.K, determine: (i) how long the potato is baked in the oven and (ii) the final equilibrium temperature of the potato after it is wrapped. **(17)**

Use the attached "Heister Chart" for your calculation.

(b) The soil temperature in the upper layers of the earth varies with variation in the atmospheric conditions. Before a cold front moves in, the earth at a location is initially at a uniform temperature of 10°C. Then the area is subjected to a temperature of -10°C and high winds that resulted in a convection heat transfer coefficient of 40 W/m^2.K on the earth's surface for a period of 10 hours. Taking the properties of the soil at that location to be k = 0.9 W/m.K and α = 1.6×10^{-5} m^2/s, determine the soil temperature at distance 10 cm from the earth's surface at the end of this 10 hour period. Also calculate the amount of heat lost per unit area from the ground in this time period. Use the attached error function table for your calculation. **(18)**

7. (a) The flow of oil in a journal bearing can be approximated as parallel flow between two parallel plates with one plate moving and another being stationary. Such flow as are commonly known as Couette flow. **(20)**

Consider two large isothermal plates separated by 2-mm-thick oil film. The upper plate moves at a constant velocity of 12 m/s, while the lower plate is stationary. Both plates are maintained at 20°C.

(i) Obtain relations for the velocity and temperature distributions in the oil.

(ii) Determine the maximum temperature in the oil and the heat flux from the oil to each plate.

Oil properties: k = 0.145 W/m.K, μ = 0.8374 kg/m.s

Contd P/4

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(b) Outline the advantages of non-dimensional analysis of engineering problem. Discuss in short the role of the following non-dimensional parameters in convective heat transfer analysis: **(15)**

(i) Prandtl number (Pr)

(ii) Grash of number (Gr)

(iii) Richardson number (R_i)

8. (a) Consider the flow of engine oil at 10 °C in a 40-cm diameter pipeline at an average velocity of 0.5 m/s. A 300-m long section of the pipeline pass through icy waters of a lake at 0 °C. Disregarding the thermal resistance of the pipe material, determine: **(20)**

(i) the temperature of the oil when the pipe leaves the lake

(ii) the rate of heat transfer from the oil, and

(iii) the pumping power required to overcome the pressure losses and to maintain the flow of oil in the pipe.

Engine oil properties have been listed in attached Table.

(b) Consider a rectangular fin that is used to cool a motorcycle engine. The fin is 0.15 m long and is at a temperature of 250 °C, while the motorcycle is moving at 80 km/h in air at 30°C. The air is in parallel flow over both surfaces of the fin, and turbulent flow conditions may be assumed to exist throughout. What is the rate of heat removal per unit width of the fin? **(15)**

Use the attached necessary heat transfer equations as well as properties of air.

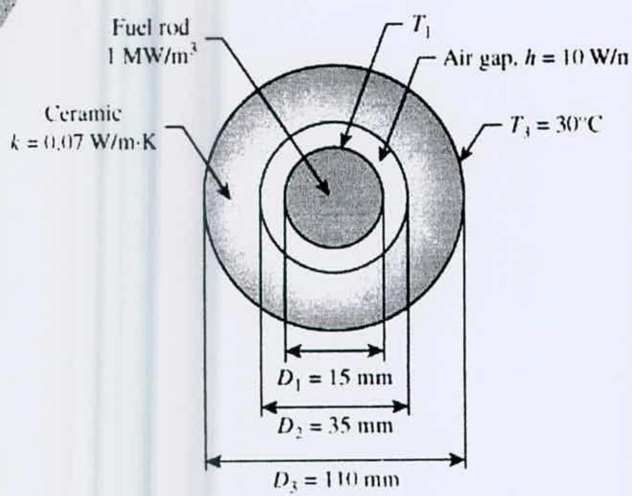


Fig. 1 for question 1(c)

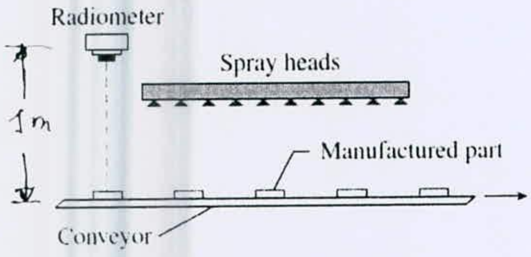


Fig. 2 for question 3(b)

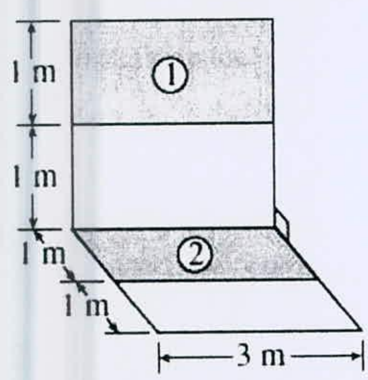


Fig. 3 for question 4(a)

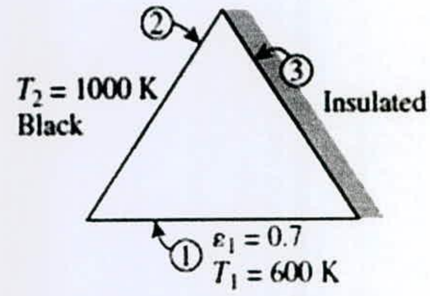
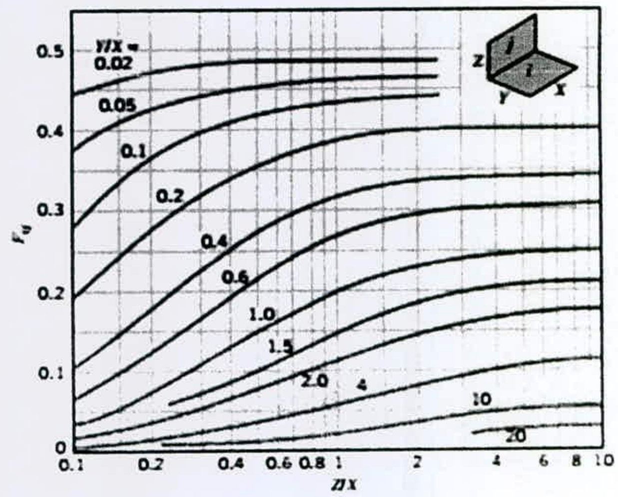


Fig. 4 for question 4(b)



$$\dot{Q}_{ij} = \frac{\sigma(T_i^4 - T_j^4)}{\frac{1-\varepsilon_i}{\varepsilon_i A_i} + \frac{1}{A_i F_{ij}} + \frac{1-\varepsilon_j}{\varepsilon_j A_j}}$$

$$\bar{h}_{horiz} = 0.729\left[\frac{g\rho_l(\rho_l - \rho_v)h^{*}_{fg}k_l^3}{\mu_l(T_{sat} - T_s)D}\right]^{1/4}$$

TABLE A–9

Properties of saturated water

Temp.	Saturation Pressure	Density ρ, kg/m³		Enthalpy of Vaporization	Specific Heat c_p, J/kg·K		Thermal Conductivity k, W/m·K		Dynamic Viscosity μ, kg/m·s		Prandtl Number Pr	
T, °C	P_{sat}, kPa	Liquid	Vapor	h_{fg}, kJ/kg	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Figures/Tables/Charts for ME 305 (Section B)

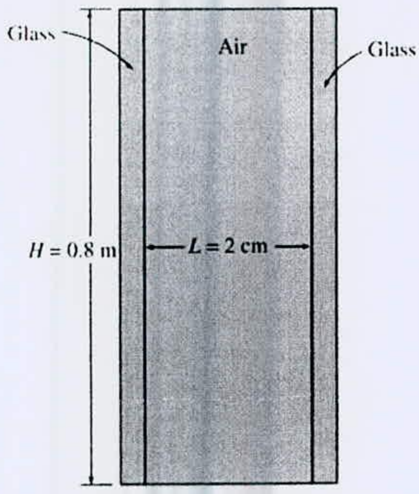
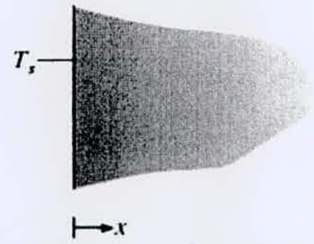


Fig. for Q. 7 (b)

Temperature Distribution in 1D Semi Infinite H.C.

$T(x, 0) = T_i$
$T(0, t) = T_s$



Constant Surface Temperature: $T(0, t) = T_s$

$$\frac{T(x, t) - T_s}{T_i - T_s} = \operatorname{erf}\left(\frac{x}{2\sqrt{\alpha t}}\right)$$

$$q_s''(t) = \frac{k(T_s - T_i)}{\sqrt{\pi \alpha t}}$$

The complementary error function

η	erfc (η)	η	erfc (η)	η	erfc (η)	η	erfc (η)	η	erfc (η)	η	erfc (η)
0.00	1.00000	0.38	0.5910	0.76	0.2825	1.14	0.1069	1.52	0.03159	1.90	0.00721
0.02	0.9774	0.40	0.5716	0.78	0.2700	1.16	0.10090	1.54	0.02941	1.92	0.00662
0.04	0.9549	0.42	0.5525	0.80	0.2579	1.18	0.09516	1.56	0.02737	1.94	0.00608
0.06	0.9324	0.44	0.5338	0.82	0.2462	1.20	0.08969	1.58	0.02545	1.96	0.00557
0.08	0.9099	0.46	0.5153	0.84	0.2349	1.22	0.08447	1.60	0.02365	1.98	0.00511
0.10	0.8875	0.48	0.4973	0.86	0.2239	1.24	0.07950	1.62	0.02196	2.00	0.00468
0.12	0.8652	0.50	0.4795	0.88	0.2133	1.26	0.07476	1.64	0.02038	2.10	0.00298
0.14	0.8431	0.52	0.4621	0.90	0.2031	1.28	0.07027	1.66	0.01890	2.20	0.00186
0.16	0.8210	0.54	0.4451	0.92	0.1932	1.30	0.06599	1.68	0.01751	2.30	0.00114
0.18	0.7991	0.56	0.4284	0.94	0.1837	1.32	0.06194	1.70	0.01612	2.40	0.00069
0.20	0.7773	0.58	0.4121	0.96	0.1746	1.34	0.05809	1.72	0.01500	2.50	0.00041
0.22	0.7557	0.60	0.3961	0.98	0.1658	1.36	0.05444	1.74	0.01387	2.60	0.00024
0.24	0.7343	0.62	0.3806	1.00	0.1573	1.38	0.05098	1.76	0.01281	2.70	0.00013
0.26	0.7131	0.64	0.3654	1.02	0.1492	1.40	0.04772	1.78	0.01183	2.80	0.00008
0.28	0.6921	0.66	0.3506	1.04	0.1413	1.42	0.04462	1.80	0.01091	2.90	0.00004
0.30	0.6714	0.68	0.3362	1.06	0.1339	1.44	0.04170	1.82	0.01006	3.00	0.00002
0.32	0.6509	0.70	0.3222	1.08	0.1267	1.46	0.03895	1.84	0.00926	3.20	0.00001
0.34	0.6306	0.72	0.3086	1.10	0.1198	1.48	0.03635	1.86	0.00853	3.40	0.00000
0.36	0.6107	0.74	0.2953	1.12	0.1132	1.50	0.03390	1.88	0.00784	3.60	0.00000

First Term Approximation Solution for 1D Transient Heat Conduction:

Plane wall:
$$\theta(x, t)_{\text{wall}} = \frac{T(x, t) - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau} \cos(\lambda_1 x/L), \quad \tau > 0.2$$

Cylinder:
$$\theta(r, t)_{\text{cyl}} = \frac{T(r, t) - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau} J_0(\lambda_1 r/r_o), \quad \tau > 0.2$$

Sphere:
$$\theta(r, t)_{\text{sph}} = \frac{T(r, t) - T_\infty}{T_i - T_\infty} = A_1 e^{-\lambda_1^2 \tau} \frac{\sin(\lambda_1 r/r_o)}{\lambda_1 r/r_o}, \quad \tau > 0.2$$

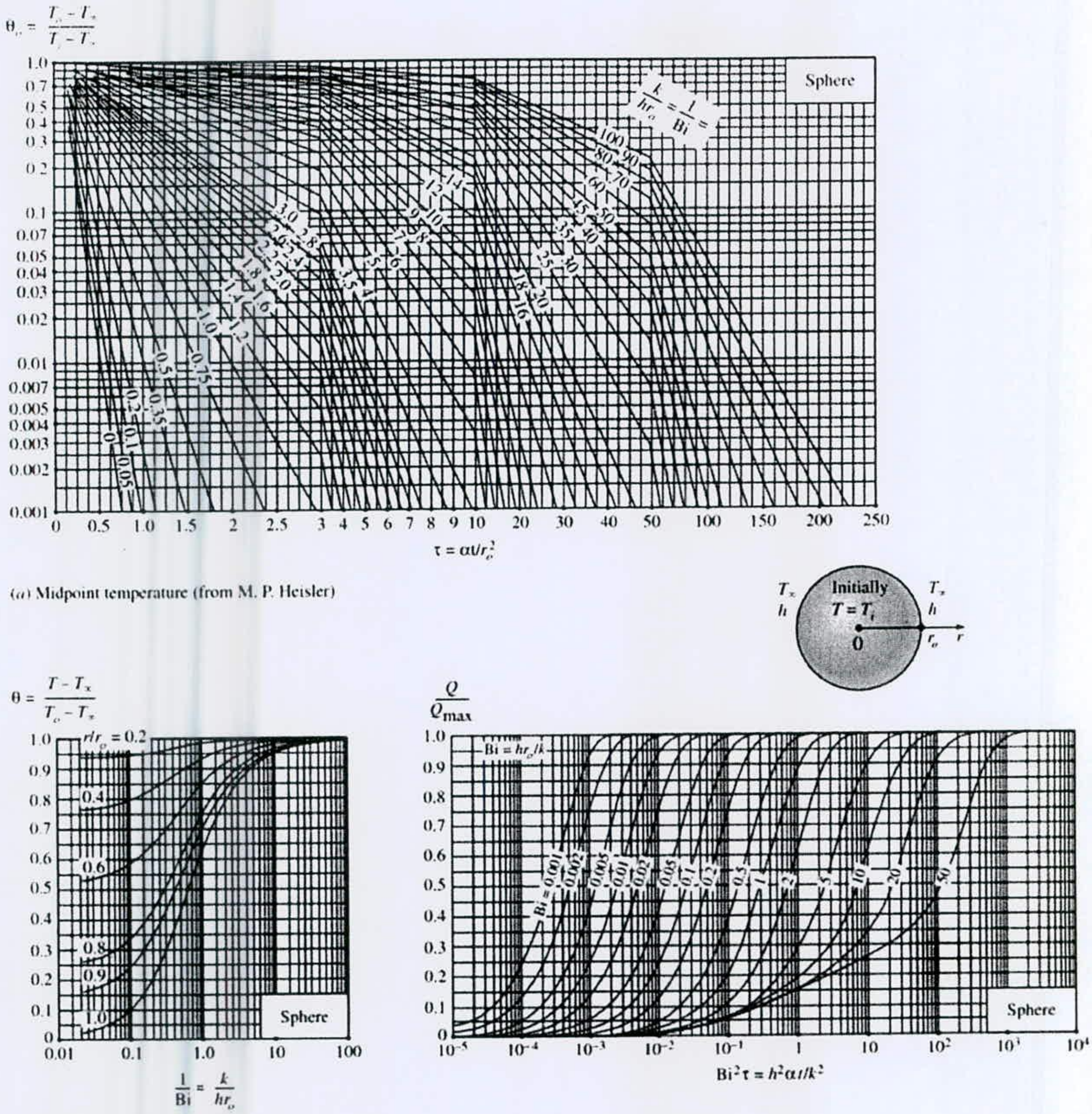
TABLE 4–1

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

Properties of Engine Oil:

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	Volume Expansion Coeff. β, 1/K
Engine Oil (unused)								
0	899.0	1797	0.1469	9.097×10^{-8}	3.814	4.242×10^{-3}	46,636	0.00070
20	888.1	1881	0.1450	8.680×10^{-8}	0.8374	9.429×10^{-4}	10,863	0.00070
40	876.0	1964	0.1444	8.391×10^{-8}	0.2177	2.485×10^{-4}	2,962	0.00070
60	863.9	2048	0.1404	7.934×10^{-8}	0.07399	8.565×10^{-5}	1,080	0.00070
80	852.0	2132	0.1380	7.599×10^{-8}	0.03232	3.794×10^{-5}	499.3	0.00070
100	840.0	2220	0.1367	7.330×10^{-8}	0.01718	2.046×10^{-5}	279.1	0.00070
120	828.9	2308	0.1347	7.042×10^{-8}	0.01029	1.241×10^{-5}	176.3	0.00070
140	816.8	2395	0.1330	6.798×10^{-8}	0.006558	8.029×10^{-6}	118.1	0.00070
150	810.3	2441	0.1327	6.708×10^{-8}	0.005344	6.595×10^{-6}	98.31	0.00070



(*a*) Midpoint temperature (from M. P. Heisler)

(*b*) Temperature distribution (from M. P. Heisler)

(*c*) Heat transfer (from H. Gröber et al.)

FIGURE 4–15

Transient temperature and heat transfer charts for a sphere of radius r_o initially at a uniform temperature T_i subjected to convection from all sides to an environment at temperature T_∞ with a convection coefficient of h.

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)	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: $5 \times 10^5 \le Re_L \le 10^7$; $0.6 \le Pr \le 60$ $Re_{cr} = 5 \times 10^5$	$C_f = 0.074 Re_L^{-1/5} - 1742 / Re_L$	$Nu_L = \left(0.037 Re_L^{4/5} - 871\right) Pr^{1/3}$	$Nu_L = \dfrac{0.037 Re_L^{4/5} Pr^{1/3}}{1 + 12.35 \times 10^6 Re_L^{-6/5}}$

MacGregor and Emery (1969) Correlations for Natural convection in vertical enclosures with larger aspect ratios:

$$Nu = 0.42\, Ra_L^{1/4}\, Pr^{0.012} \left(\frac{H}{L}\right)^{-0.3} \qquad \begin{array}{l} 10 < H/L < 40 \\ 1 < Pr < 2 \times 10^4 \\ 10^4 < Ra_L < 10^7 \end{array}$$

$$Nu = 0.46 Ra_L^{1/3} \qquad \begin{array}{l} 1 < H/L < 40 \\ 1 < Pr < 20 \\ 10^6 < Ra_L < 10^9 \end{array}$$

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

L-3/T-1/ME **Date: 07/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

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**.

1. (a) What do you mean by 'Continuum'? What is the usefulness of introducing this concept in the study of fluid mechanics? **(5)**

(b) Show the rheological behavior of various materials in a graph. **(5)**

(c) Calculate the approximate power lost in friction in this ship propeller shaft bearing shown in Fig Q1.c. **(13)**

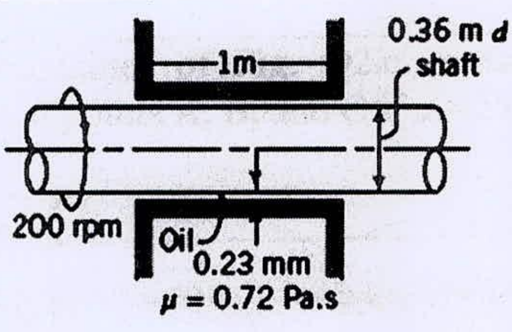


Fig. Q1.c

(d) For the inclined manometer containing mercury, shown in Fig. Q1.d, determine the pressure in pipe B if the pressure in pipe A is 15 kPa. Pipe A has water flowing through it, and oil is flowing in pipe B. **(12)**

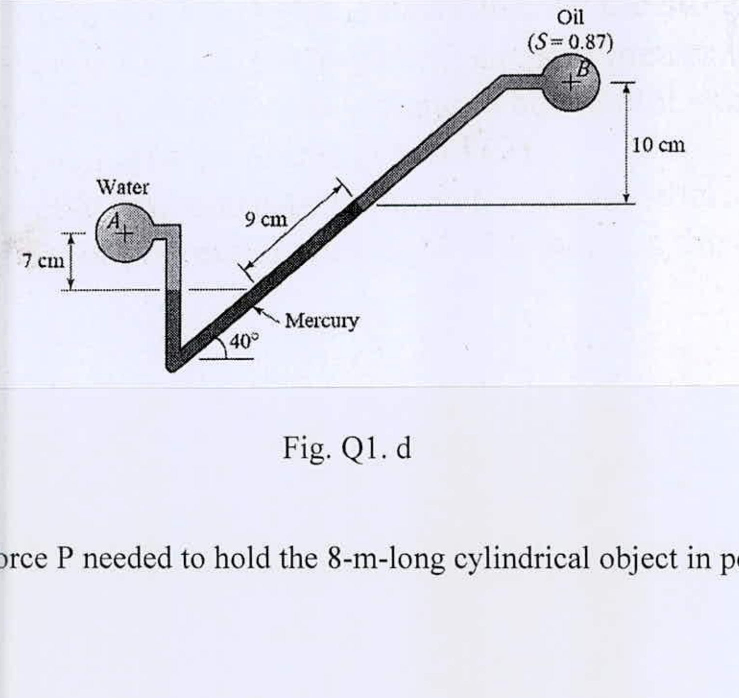


Fig. Q1. d

2. (a) Find the force P needed to hold the 8-m-long cylindrical object in position as shown in Fig. Q2.a. **(15)**

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Contd... Q. No. 2

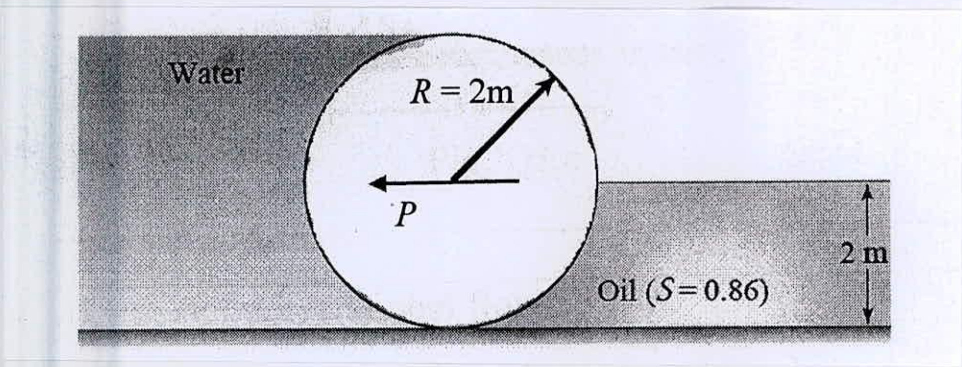

Fig. Q2. a

(b) What do you mean by "rigid body motion" of a fluid system? **(4)**

(c) The 2.5 m high container of Fig. Q2.c contains 2.0 m deep water. Determine the pressure at point A, B, and C if $a_x = 25\ m/s^2$, $a_z = 15\ m/s^2$. **(16)**

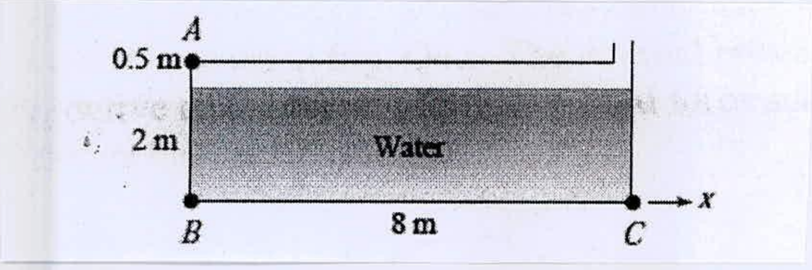

Fig. Q2. c

3. (a) Deduce an equation for the metacentric height of a floating body. **(12)**

(b) Show that the difference in the values of the stream function of two streamlines gives the flow rate between those streamlines. **(7)**

(c) The two-dimensional flow of nonviscous, incompressible fluid in the vicinity of the 90° corner of Fig. Q3.c is described by the stream function $\Psi = 2r^2 \sin 2\theta$, where Ψ has units of m^2/s when r is in meters. Assume the fluid density is 1000 kg/m^3 and the x-y plane is horizontal - that is, there is no difference in elevation between points (1) and (2). **(16)**

- Determine, if possible, the corresponding velocity potential.
- If the pressure at point (1) on the wall is 34 kPa, what is the pressure at point (2)?

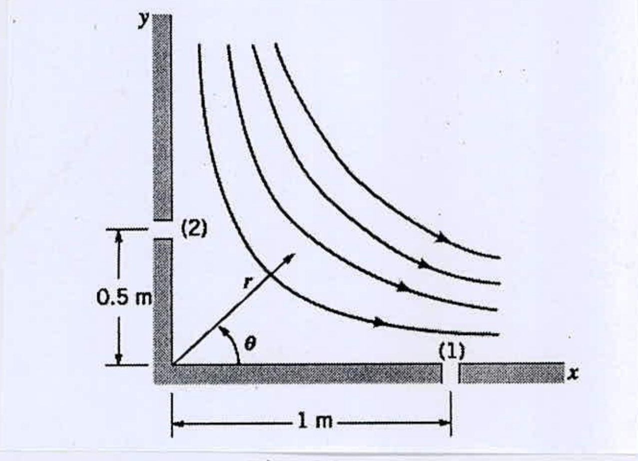

Fig. Q3.c

Contd P/3

4. (a) What do you mean by irrotational flow? **(6)**

(b) Consider a line source at origin $(0, 0)$ of strength, Λ in a uniform flow with velocity V_∞ along (+ve) x axis. **(14)**

- Write down the stream function for this combined flow field.
- Determine the magnitude of the velocity on or outside the body.
- Determine the location of the stagnation point and nose distance.

(c) Wind at U_∞ and p_∞ flows past a Quonset hut which is a half-cylinder of radius a and length L, shown in Fig. Q4.c. The internal pressure is p_i. Using inviscid theory, derive an expression for the upward force acting on the hut due to the difference between p_i and p_s. **(15)**

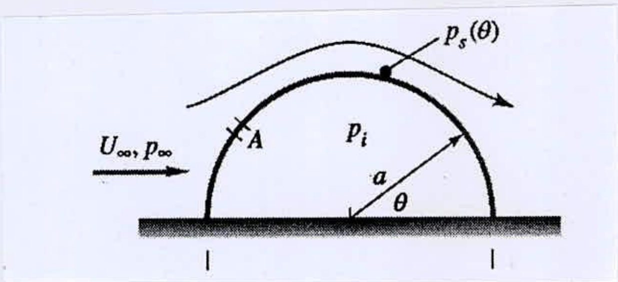

Fig. Q4.c

Suppose that a hole is introduced in the hut roof at point A to make p_i equal to the surface pressure there. At what angle should hole A be placed to make the net wind force zero?

SECTION – B

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

Symbols have their usual meaning. Assume reasonable values for missing data.

5. (a) 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) The velocity vector V for a steady incompressible flow is given by $\mathbf{V} = ax\mathbf{i} - by\mathbf{j}$. **(10)**

(i) Determine the equation of streamlines and sketch them.

(ii) Locate the stagnation point if there is any.

Contd P/4

ME 321

Contd... Q. No. 5

(c) The solid propellant rocket shown in Fig. for Que. No. 5(c) is self-contained and has no entrance ducts. Using a control volume analysis for the conditions shown, compute the rate of mass loss of the propellant, assuming that the exit gas has a molecular weight of 28. **(10)**

6. (a) Using Reynolds Transfer Theorem, deduce the expression for the integral form of the linear momentum equation in context of fluid dynamics. **(7)**

(b) Derive the Bernoulli's equation and show the Energy form, Head form and Pressure form of the Bernoulli's equation and identify the terms. **(15)**

(c) Water is drawn into the pump (shown in Fig. for Que No. 6(c), such that the pressure at the inlet A is -35 kPa and the pressure at B is 120 kPa. If the discharge at B is 0.08 m^3/s. determine the power output of the pump. Neglect frictional losses. The pipe has a constant diameter of 100 mm. Take h = 2 m. Also draw the energy and hydraulic grade lines for the pipe ACB. **(13)**

7. (a) Write down the Navier-Stokes equations for a 3-D viscous, incompressible flow in Cartesian coordinate system (x, y, z). **(5)**

(b) The fluid velocity along the x axis changes from 6 m/s at point A to 18 m/s at point B as shown in Fig. for Que. No. 7(b). It is also known that the velocity is a linear function of distance along the streamline. Determine the acceleration at points A, B and C. Assume steady flow. **(12)**

(c) Water flows through the pipe C at 4 m/s as shown in Fig. for Que. No. 7(c). Determine the force exerted by elbow D necessary to hold the pipe assembly in equilibrium. Neglect the size and weight of the pipe and the water within it. The pipe bas a diameter of 60 mm at C and at A and B the diameters are 20 mm. The fluid exits at A and B to the atmosphere. **(18)**

8. (a) Write down the merits and demerits of orificementer and venturimeter. Derive an expression of actual flow rate through an orificmemeter. **(12)**

(b) A venturimeter shown in Fig. for Que. No. 8(b) is fitted in a pipe of 30 cm diameter inclined at 40° to the horizontal to measure the flow rate of petrol having a specific gravity of 0.8. The ratio of areas of main pipe and throat is 5 and the throat is at 1 m from the inlet along its length. The difference in manometer head is 40 mm of mercury. Assuming the coefficient of discharge as 0.96. Calculate the discharge through the venturimeter and the pressure difference between the throat and the entry point of the venturimeter. **(12)**

(c) Oil flows through the system shown in Fig. for Que. No. 8(c) with negligible losses. Determine the flowrate. **(11)**

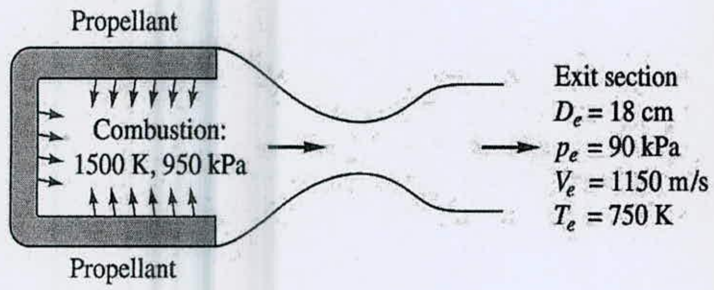

Fig. for Que. No. 5(c)

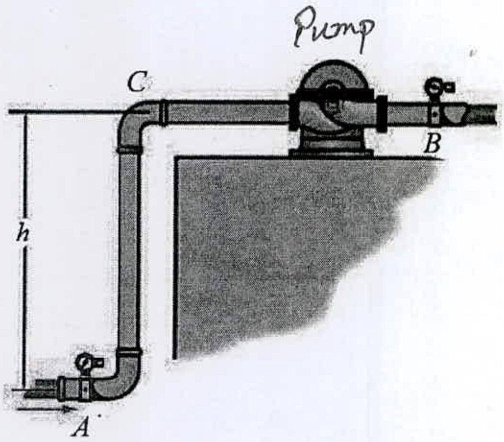

Fig. for Que. No. 6(c)

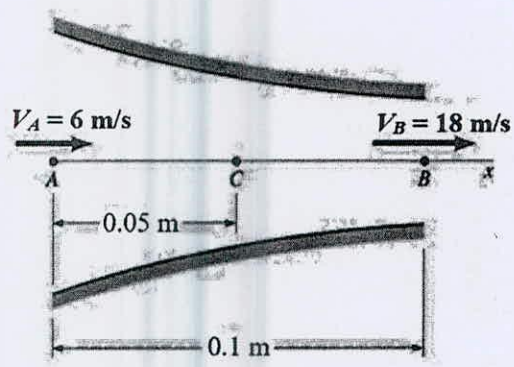

Fig. for Que. No. 7(b)

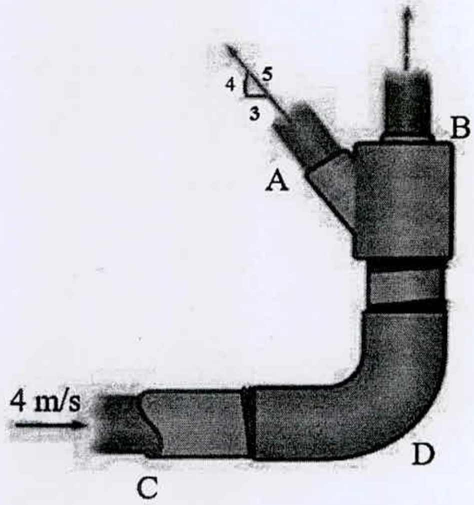

Fig. for Que. No. 7(c)

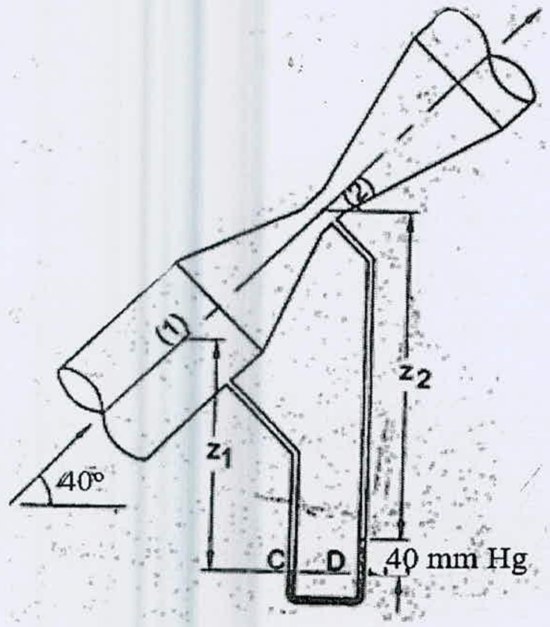

Fig. for Que. No. 8(b)

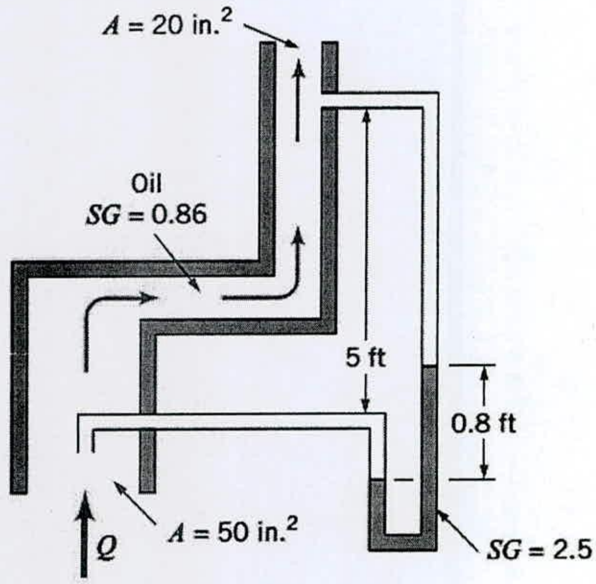

Fig. for Que. No. 8(c)

L-3/T-1/ME **Date: 30/03/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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** questions.

Symbols indicate their usual meanings. Assume any missing data.

1. (a) Fig. 1(a) shows diagrammatically a compound epicyclic gear train. Wheels A, D and E are free to rotate independently on spindle O, while B and C are compound and rotate together on spindle P, on the end of arm OP. All the teeth on different wheels have the same module. A has 12 teeth, B has 30 teeth and C has 14 teeth cut externally. Find the number of teeth on wheels D and E which are cut internally. If the wheel A is driven clockwise at 1 r.p.s. while D is driven counter clockwise at 5 r.p.s, determine the magnitude and direction of the angular velocities of arm OP and wheel E. **(18)**

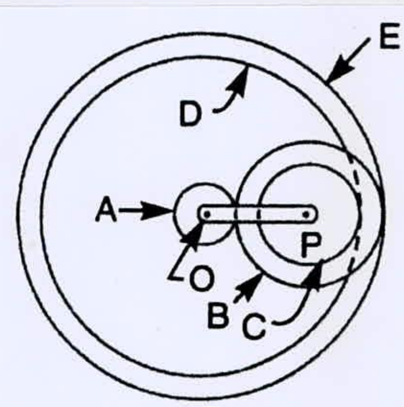

Fig. for Question 1(a)

(b) Two mating gears have 20 and 40 involute teeth of module 10 mm and 20° pressure angle. The addendum on each wheel is to be made of such a length that the line of contact on each side of the pitch point has half the maximum possible length. Determine the addendum height for each gear wheel, length of the path of contact, arc of contact and contact ratio. **(17)**

2. (a) The six cylinder of a single-acting, two stroke cycle diesel engine are pitched 1 m apart and the cranks are spaced at 60° intervals. The crank length is 300 mm and the ratio of connecting rod to crank is 4.5. The reciprocating mass per line is 1.35 Mg and the rotating mass is 1 Mg. The speed is 200 rev/min. Show with regard to primary and secondary balance, that the firing order 1-5-3-6-2-4 gives unbalance in primary moment only, and the order 1-4-5-2-3-6 gives secondary moment unbalance only. Compare the maximum values of these moments, evaluating with respect to the central plane of the engine. **(18)**

Contd P/2

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Contd.... for Q. No. 2

(b) An underdamped shock absorber is to be designed for a motorcycle of mass 200 kg. When the shock absorber is subjected to an initial vertical velocity due to a road bump, the resulting displacement-time curve is given in Fig. 2(b). Find the necessary stiffness and damping constants of the shock absorber if the damped period of vibration is to be 2 s and the amplitude x_1 is to be reduced to one-fourth in one half cycle. Also find the minimum initial velocity that leads to a maximum displacement of 250 mm. **(17)**

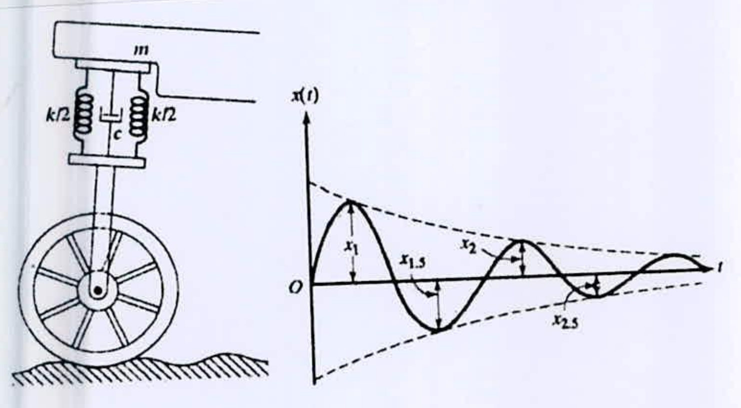

Fig. for Question 2 (b)

3. (a) The schematic diagram of a marine engine connected to a propeller through gears is shown in Fig. 3(a). The mass moments of inertia of the flywheel, engine, gear 1, gear 2, and the propeller (in kg-m^2) are 9000, 1000, 250, 150 and 2000 respectively. Find the natural frequencies and mode shapes of the system in torsional vibration. **(20)**

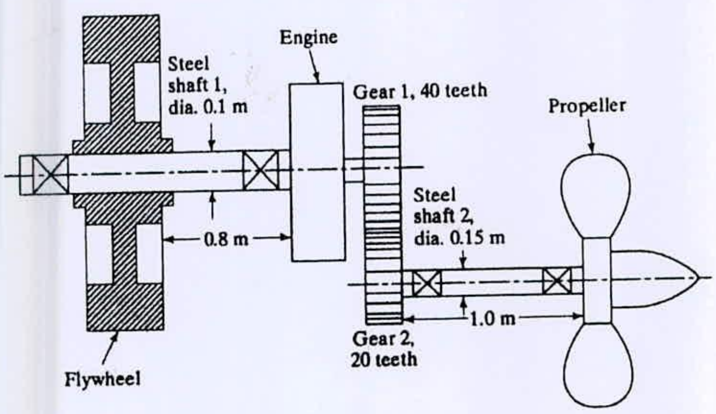

Fig. for Question 3 (a)

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Contd.... for Q. No. 3

(b) A uniform slender rod of mass m and length l is hinged at point A and is attached to four linear springs and one torsional spring, as shown in Fig. 3(b). Find the natural frequency of the system if $k = 2000$ N/m, $k_t = 1000$ N-m/rad, $m = 10$ kg and $l = 5$ m. **(15)**

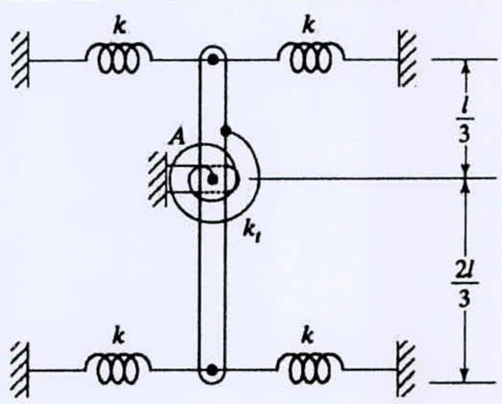


Fig. for Question 3 (b)

4. Draw the cam profile when the roller follower moves with cycloidal motion during both the out stroke and return stroke, as given below: **(35)**

   (i) Out stroke with maximum displacement of 31.4 mm during 180° of cam rotation,

   (ii) Return stroke for the next 150° of cam rotation,

   (iii) Dwell for the remaining 30° of cam rotation.

The minimum radius of the cam is 15 mm and the roller diameter of the follower is 10 mm. The axis of the roller follower is offset by 10 mm towards right from the axis of cam shaft. Determine the maximum acceleration during both the out stroke and return stroke when the cam shaft rotates at 100 r.p.m.

SECTION – B

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

5. (a) Two shafts A and B are connected by a friction clutch. Keyed to shaft B is a spur wheel of 90 teeth gearing with a pinion of 30 teeth on the driving motor shaft. With the clutch disengaged and power switched off from the motor the shaft A is at rest and the motor pinion is rotating at 900 rev/min. If the clutch is suddenly engaged determine the common speed of A and B when slipping has ceased. Details of the component parts are: **(17)**

Components	Mass (Kg)	Radius of gyration (mm)
Shaft A assembly	200	300
Shaft B assembly	90	150
Motor pinion and armature	22	75

ME 349

Contd.... for Q. No. 5

(b) A solo motorcycle, complete with a rider, has a mass of 225 kg, the center of gravity being 0.6 m above ground level. The moment of inertia of each road wheel is 1.0 kg-m^2 and the rolling diameter is 0.6 m. The engine crankshaft rotates, in the same sense as the wheels, at 5 times the speed of the wheels. The rotating parts of the engine are equivalent to a flywheel whose moment of inertia is 0.2 kg-m^2. Determine the heel-over angle required when the unit is traveling at 100 km/h in a curve of radius 60 m. **(18)**

6. (a) A rotating shaft carries four masses A, B, C and D which are radially attached to it. The mass centers are 30 mm, 38 mm, 40 mm and 35 mm respectively from the axis of rotation. The masses A, C and D are 7.5 kg, 5 kg and 4 kg respectively. The axial distance between the planes of rotation of A and B is 400 mm and between B and C is 500 mm. The masses A and C are at right angles to each other. Find for a complete balance, **(17)**

   (i) the angular position of the masses B and D from mass A,
   (ii) the axial distance between the planes of rotation of B and D,
   (iii) the magnitude of mass B.

   (b) An engine is fitted with a flywheel which has a mass of 22.5 kg and a radius of gyration of 0.2 m. The load torque is constant and the crankshaft torque can be represented by the expression **(18)**

$$\text{Torque} = 4a + a\sin\theta + a\sin 2\theta$$

   Where θ is the crank angle.

   When he engine develops 7.5 kW at 600 rev/min, find the following:

   (i) the crank angle at which the engine torque is equal to the load torque,
   (ii) the coefficient of cyclical speed fluctuation,
   (iii) the maximum angular acceleration of the flywheel.

7. (a) An open belt, having a mass of 1.2 kg/m run, is used to transmit power from a 0.9-m diameter pulley running at 250 rev/min to one running at 450 rev/min. The distance between the pulley centers is 3.15 m. If the initial tension is 465 N, determine the power which can be transmitted when the coefficient of friction is 0.25. **(17)**

   (b) The figure for Q. 7(b) shows a brake drum 330 mm in diameter, acted on by two brake shoes which are mounted on pin A, and pushed apart by two hydraulically operated pistons at B, each exerting a force of P N on the shoe on which it makes contact. The brake lining on each shoe extends 60° above to 60° below the horizontal center line. The coefficient of friction is 0.2. The radial pressure between the lining and the drum is proportional to the rate of wear of the lining. **(18)**

Contd P/5

ME 349

Contd.... for Q. No. 7(b)

Find the value of P to produce a braking torque of 180 Nm.

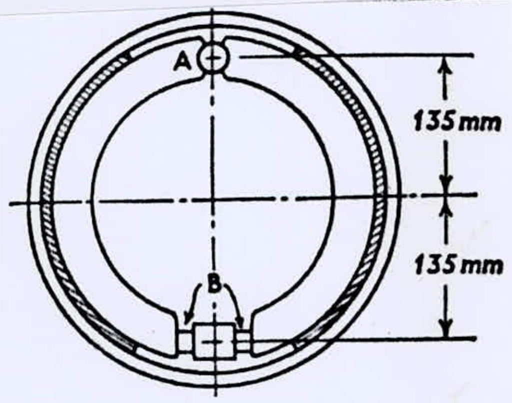


Figure for Q. 7(b)

8. A slider A, as shown in Figure for Q. 8, of mass 1.8 kg, moves along horizontal guides, whilst another slider B, of mass 2.7 kg, moves in vertical guides. The two sliders are joined by a light connecting rod 200 mm long. The coefficient of friction at the sliding surfaces is 0.08, whilst friction at turning pairs may be neglected. **(35)**

Find the horizontal force P required to drive the mechanism at an instant when angle BAO is 60°, the velocity of A then being 0.9 m/s to the right, and the acceleration of A 1.5 m/s^2 to the right.

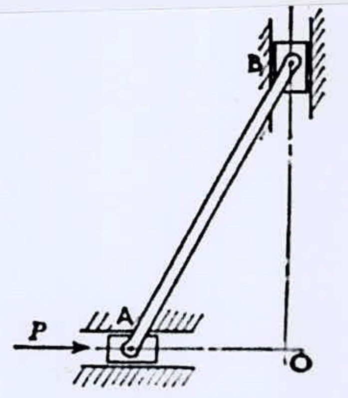


Figure for Q. 8

L-3/T-1/ME Date : 06/04/2023

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

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**.

Symbols indicate their usual meaning.

1. (a) A square wave with period T that goes between $\pm V_0$ is applied to the RC circuit of Fig. 1(a). Plot $V_{CAP}(t)$ for: **(9)**

(i) $RC << T$

(ii) $RC >> T$

(iii) $RC \approx T$

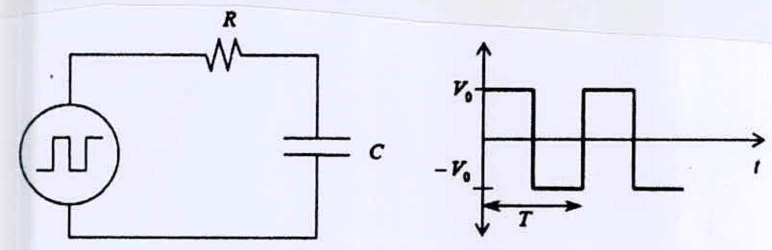


Fig. 1a

(b) What should the SNR be at a measurement system's detection limit? From the definition of SNR, discuss. **(5)**

(c) With proper diagram, discuss repeatability error and zero shift error. **(6)**

(d) The Fourier series of a rectified voltage signal, E(t) = |120 sin(120πt)| is "76.4 – 50.93 cos (240πt) – 10.10 cos(480πt) – 4.37 cos(720πt) …". Sketch an amplitude spectrum plot for this series. **(7)**

(e) How many significant digits are present in the following numbers? **(8)**

(i) 10.0

(ii) 0.0045

(iii) 2500

(iv) 042.02

Contd P/2

ME 361

2. (a) Predict he steady output signal from a second-order instrument having $K = 1$ unit/unit, $\zeta = 2$, and $\omega_n = 628$ rad/s, which is used to measure the following input signal. **(20)**

   $F(t) = 5 + 10\sin(25t) + 20\sin(867t)$; the first term is the DC offset, the second term is an unwanted signal, and the third term is the signal to be measured.

   Sketch the amplitude spectrum of the input and output signals. Is this instrument a good choice for the measurement system? Discuss.

   (b) A temperature sensor is to be selected to measure the temperature within a reaction vessel. It is suspected that the temperature will behave as a simple periodic waveform with a frequency somewhere between 5 and 15 Hz. Sensors of several sizes are available, each with a known time constant. Based on time constant, select a suitable sensor, if a dynamic error of ± 2% is acceptable. **(15)**

3. (a) Suppose an Op-amp is to be used to integrate a signal over the time of 1 ms. Design a circuit to accomplish this objective. **(10)**

   (b) Write short note on the following topics: **(15)**

   (i) Instrumentation amplifier

   (ii) 4-20 mA current loop

   (iii) Signal grounding arrangements

   (c) In a certain chemical-processing plant, a liquid chemical is used in a manufacturing process. The chemical is stored in three different tanks. A level sensor in each tank produces a LOW voltage when the level of chemical in the tank drops below a specified point. Design a circuit that monitors the chemical level in each tank and indicates when the level in any two of the tanks drops below the specified point. **(10)**

4. (a) An experimental analysis of the natural oscillations in a particular structure shows the dominant frequencies of interest appear at below 200 Hz. However, frequency information also exists at 350, and 450 Hz. If the signal is sampled at 400 Hz, how will the information in the aliased frequencies appear in the sampled data? How can one prevent this information from being superposed onto the desired signal? **(12)**

   (b) Discuss the trade-offs between resolution and conversion times for successive approximation, ramp, and parallel converters. **(12)**

   (c) Write a short note on "virtual instrumentation". **(11)**

Contd P/3

SECTION – B

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

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

5. (a) Define calibration. Why is it done? **(5)**

   (b) What are the different signal conditioning functions? Mention some devices and/or modulus used for accomplishing those functions. **(9)**

   (c) Describe with sketches the functioning of a Bourdon-tube pressure-gauge equipped with an LVDT type sensor. **(12)**

   (d) Illustrate the significance of "gain", "saturation" and "hysteresis" characteristics of a sensor. **(9)**

6. (a) What is the working principle of a piezoelectric sensor? **(5)**

   (b) Mention the types of pressure that might exist in a stream of fluid flowing over a solid body. Show how Pitot-tube and/or Pitot-static tube is/are used to measure those different types of pressure. **(9)**

   (c) What is vena contracta? Derive an expression for flow measurement in a pipe by an orificemeter and show that for a given setup, the actual flow-rate depends only on the manometric deflection. **(12)**

   (d) Describe the construction and operation of a bimetallic strip thermometer. **(9)**

7. (a) What is the use of a 'proving ring'? **(5)**

   (b) Explain the operation of an ultrasonic flowmeter. Mention its merits and demerits. **(9)**

   (c) For which measured, a dynamometer is used? Derive the expression for mechanical power obtained from a mechanical brake type dynamometer equipped with a tachometer. **(12)**

   (d) What is RTD? Mention its advantages and disadvantages. **(9)**

8. (a) Is there any similarity in the working principle of a 'Pirani gauge' and an 'Ionization Gauge'? – Explain. **(5)**

   (b) Explain the differences between the following terms used in measurement: **(12)**

   (i) accuracy vs precision, (ii) error vs uncertainty, (iii) repeatability vs reproducibility, (iv) random error vs systematic error.

Contd P/4

ME 361

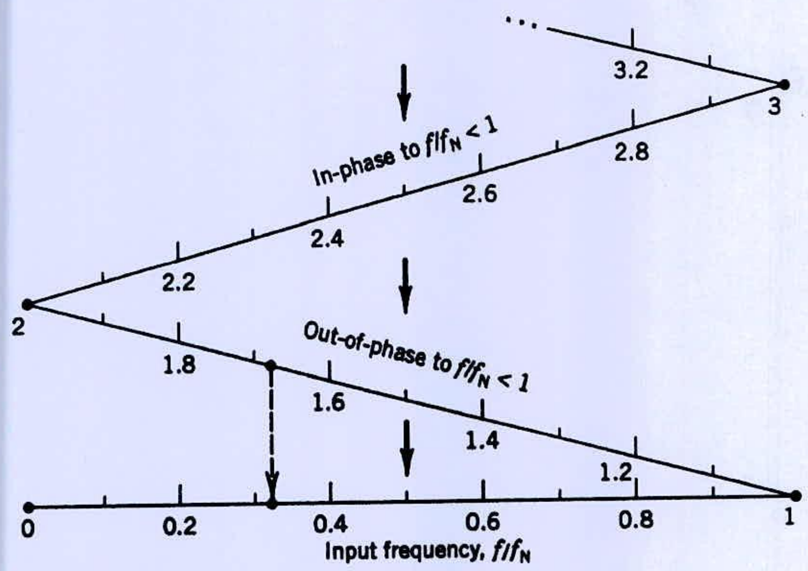
Contd … Q. No. 8

(c) From 19 measurements of a pressure controller, the mean operating pressure is 4.97 kPa with a standard deviation of 0.0461 kPa. Neglecting other sources of error, state the population true mean pressure at 95% confidence. Use the following table. **(9)**

Table for Q. 8(c): Student's t Distribution (Two-Tailed)

ν	t_{50}	t_{90}	t_{95}	t_{99}
1	1.000	6.314	12.706	63.657
2	0.816	2.920	4.303	9.925
3	0.765	2.353	3.182	5.841
4	0.741	2.132	2.776	4.604
5	0.727	2.015	2.571	4.032
6	0.718	1.943	2.447	3.707
7	0.711	1.895	2.365	3.499
8	0.706	1.860	2.306	3.355
9	0.703	1.833	2.262	3.250
10	0.700	1.812	2.228	3.169
11	0.697	1.796	2.201	3.106
12	0.695	1.782	2.179	3.055
13	0.694	1.771	2.160	3.012
14	0.692	1.761	2.145	2.977
15	0.691	1.753	2.131	2.947
16	0.690	1.746	2.120	2.921
17	0.689	1.740	2.110	2.898
18	0.688	1.734	2.101	2.878
19	0.688	1.729	2.093	2.861
20	0.687	1.725	2.086	2.845
21	0.686	1.721	2.080	2.831
30	0.683	1.697	2.042	2.750
40	0.681	1.684	2.021	2.704
50	0.680	1.679	2.010	2.679
60	0.679	1.671	2.000	2.660
∞	0.674	1.645	1.960	2.576

(d) In order to determine the density of a test specimen of a metal alloy, its mass is measured as 674.4 g with an uncertainty of 1.0 g and the volume of the specimen is measured as 261.1 mL with an uncertainty of 0.1 mL. Calculate the uncertainty in density determination. **(9)**



The folding diagram for alias frequencies.

L-3/T-1/ME **Date: 13/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2021-2022

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

Full Marks: 280 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** questions.

Assume reasonable value for any missing data.

1. (a) "For grinding a soft material, hard wheel should be used and vice versa" - why? **(10)**

(b) With necessary sketches, briefly describe different types of work holding devices used in a lathe machine? **(15)**

(c) Compute the machining time to turn the dimensions given in Fig. 1(c): The material is brass (60 mm φ × 145 mm), the cutting speed with HSS tool being 60 m/min, the feed is 7.5 mm/rev, depth of cut is 3 mm per pass. **($21\frac{2}{3}$)**

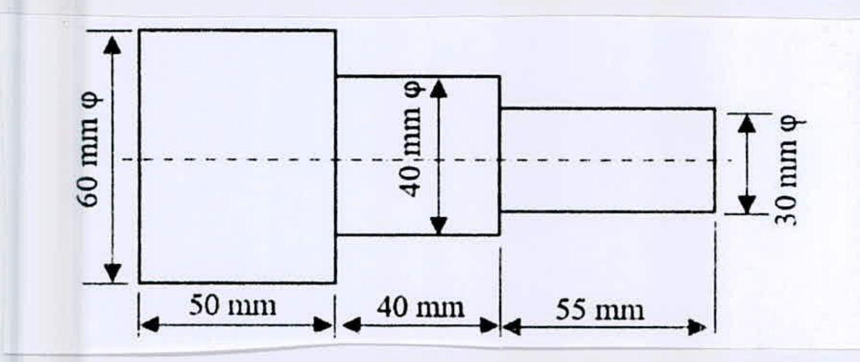


Fig. 1(c)

2. (a) Briefly describe the effect of feed per stroke on product surface finish in case of shaping. **(8)**

(b) Compare shaping and planing operation based on their differences and similarities. **(15)**

(c) Derive an expression for approach length (A) required in a milling operation. **(8)**

(d) With necessary sketches differentiate up milling and down milling methods. Which one is preferred between them? **($15\frac{2}{3}$)**

3. (a) Explain with sketches, some good design practices for extrusions? **(10)**

(b) What is creep feed grinding operation? How it differs from the conventional grinding operation? **(10)**

Contd P/2

IPE 331/ME

Contd... Q. No. 3

(c) A drilling operation is to be performed with a 25.4 mm diameter twist drill in a steel work-part. The hole is a blind-hole at a depth of 50 mm, and the point angle is 100°. Cutting conditions for drilling are: speed = 25 m/min, feed = 0.25 mm/rev. Determine: **(13)**

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

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

(d) What is spreading in flat rolling and how can it be controlled? List the defects commonly observed after flat rolling. **$(6+7\frac{2}{3}=13\frac{2}{3})$**

4. (a) How open die forging can be used for reducing diameter of a solid bar and thickness of a ring? Explain with sketches. **(08)**

(b) With the help of diagram, discuss the following: **(16)**

(i) Precision forging

(ii) Cogging operation

(iii) Coining operation

(iv) Heading operation

(c) How will you manufacturer an "aluminum beverage can" using metal forming processes? Explain each process with neat sketch. **(12)**

(d) Briefly describe some shearing operations used in sheet metal cutting. **$(10\frac{2}{3})$**

SECTION – B

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

Make appropriate Assumptions for any missing data.

5. (a) What is sand casting? Discuss the necessity of vents, risers, runners, and chills in a sand mold. **(15)**

(b) Why are match-plate patterns advantageous over split patterns in casting? What features should be considered when selecting a pattern material? Explain briefly. **(15)**

(c) Describe briefly the investment casting with necessary sketch. What are the advantages and limitations of investment casting in comparison with sand-mold casting? **$(16\frac{2}{3})$**

IPE 331/ME

6. (a) What are the differences between orthogonal cutting and oblique cutting? **($6\frac{2}{3}$)**

(b) With appropriate sketches, briefly describe the different angles of a single-point cutting tool. **(10)**

(c) What do you mean by "Master Line"? Prove the followings by master line methods for a single-point cutting tool. **(30)**

i) $\tan \gamma_0 = \tan y_x \sin \varphi + \tan \gamma_y \cos \varphi$

i) $\tan \lambda = -\tan \gamma_x \cos \varphi + \tan \gamma_y \sin \varphi$

Here, all the symbols carry their usual meaning.

Determine the value of the orthogonal rake angle of the turning tool whose geometry is specified as 5°, 10°, 7°, 8°, 20°, 30°, and 1/32 (inch).

7. (a) Differentiate positive rake angles from negative rake angles with neat sketches. **($6\frac{2}{3}$)**

(b) Explain the basic types of chips in the machining process and mention the conditions responsible for their formation. Write down the properties of a good cutting fluid. **(10+5=15)**

(c) With reference to the Merchant Circle Diagram, deduce the relationship relevant to forces in different directions of the conventional turning process, shear force, and normal to shear force.

In orthogonal cutting, if the cutting force is 900 N, the thrust force is 600 N, the feed force is zero, and the shear angle is 30°, calculate the shear force. **(25)**

8. (a) Distinguish between autogenous, homogeneous, and heterogenou welding. Briefly describe the common defects encountered with welding products with the necessary sketches. **(15)**

(b) Explain the different types of weld joints with appropriate sketches. What is the purpose of using flux and filler rod in welding operations? **(15)**

(c) With the help of a neat sketch, briefly enumerate the operating principles of the MIG welding process. What are the similarities and difference between the TIG and MIG welding processes? **($16\frac{2}{3}$)**
