L-3/T-1/ME Date : 07/06/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **ME 345** (Mechanics of Machinery)

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**.

Symbols have usual meanings.

1. (a) A spring of stiffness 5.6 kN/m and mass of 1.2 kg, is attached to a disc of diameter 150 mm, mass 1.0 kg and a block of mass 1.5 kg as shown in Figure for Q. 1(a). The disc can rotate about its center. A uniform bar of length 300 mm and mass 0.5 kg is attached to the disc as shown. Determine the equivalent mass against the spring and the natural frequency of free vibration of the system. **(23)**

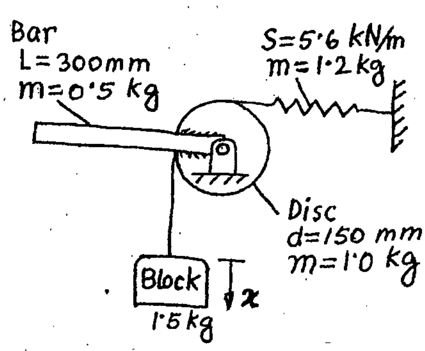

Figure for Q. 1(a)

(b) A mass of 100 kg is suspended from a spring of stiffness 4.5 kN/m. The upper end of the spring is given simple harmonic motion in a vertical direction by means of a crank 6 mm long. Determine the total movement, up and down, of the suspended mass and also its maximum velocity, if the crank is driven at 20 rad/s. **($23\frac{2}{3}$)**

2. (a) A light shaft supported in bearings at its ends carries a rotor of mass m at the center of its length. When displaced laterally the elastic restoring force due to flexure of the shaft is S per unit deflection. If, when at rest, the center of gravity of the rotor is at distance e from the axis of rotation, show that at a speed ω rad/s the elastic deflection of the shaft at the center is **(23)**

$$y = \omega^2 e \Big/ \left(\frac{S}{m} - \omega^2\right)$$

and describe the change in y as the speed is increased from zero to a large value.

If e = 0.5 mm and the whirling speed is observed to be 750 rev/min, find the speed range over which the magnitude of y will exceed 1.25 mm.

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Contd ... Q. No. 2

(b) Two rotors I_1 and I_2 are mounted on a shaft, 45 mm diameter, with a free length of 530 mm between them. At a distance of 330 mm from I_1 it is desired to take off a drive which shall be free from oscillating movement and to effect this the remaining 200 mm of shaft adjacent to I_2 is reduced in diameter. For I_1, the mass is 40 kg and the radius of gyration is 140 mm, and for I_2 the mass is 18 kg and the radius of gyration is 160 mm. Find the frequency of torsional vibration for the system and the diameter of the reduced portion of the shaft. **($23\frac{2}{3}$)**

3\. (a) Show that gear teeth with involute profiles will give a constant velocity ratio between two gear wheels. Also deduce an expression for velocity of sliding in the mating teeth. From the expression specify when/where the velocity of sliding is maximum. **(23)**

(b) In the epicyclic gear as shown in Figure for Q. 3(b), a disc P attached to shaft X carries three pins on which three sets of compound wheels, A and B, revolve freely. Wheel A mesh with an annular wheel D fixed to the casing, and wheel B mesh with wheel C attached to shaft Y. Find (i) the number of teeth on D, and (ii) the velocity ratio between X and Y. The wheel particulars are given below: **($23\frac{2}{3}$)**

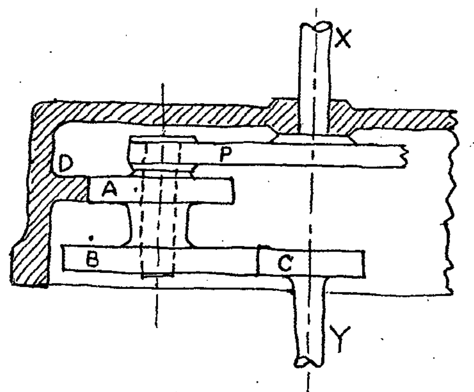

Figure for Q. 3(b)

Wheel	Number of teeth	Module (mm)
A	16	8
B	32	5
C	16	5

4\. (a) Figure for Q. 4(a) shows a uniform disc of 150 mm diameter and mass 5 kg mounted centrally in bearings which maintain its axle in a horizontal plane. The disc spins about its axle with a constant speed of 1000 rev/min while the axle precesses uniformly about the vertical turning 1 rev in 1s. The directions of rotations are as shown. If the distance between the bearings is 100 mm, find the resultant reaction at each (due to weight and gyroscopic effects) and show clearly on the sketch the points of contact between axle and bearing. **(23)**

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Contd ... Q. No. 4(a)

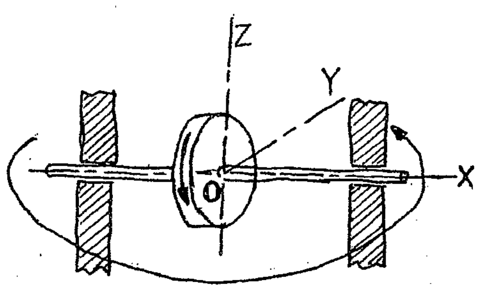


Figure for Q.4(a)

(b) The details of an externally applied brake are given in Figure for Q. 4(b). The brake is pivoted about the fixed pin at C and is operated by the force F which acts at right angles to OD. The brake lining is of uniform width, it subtends an angle of 75° at the drum shaft O and it obeys Hooke's law in compression. The angle of friction between the lining and the drum is 20° and the drum has a diameter of 200 mm. **(23⅔)**

When the drum is rotating clockwise the brake is applied with the force F = 135 N. Determine the braking torque on the drum.

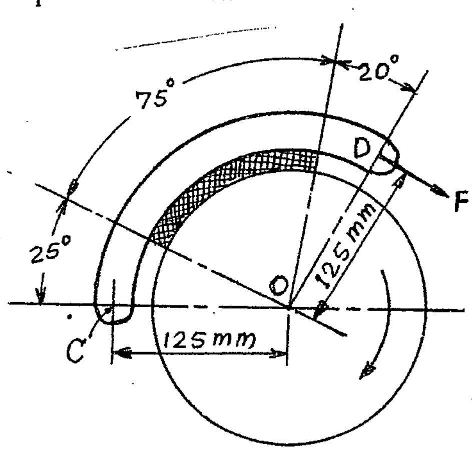


Figure for Q.4(b)

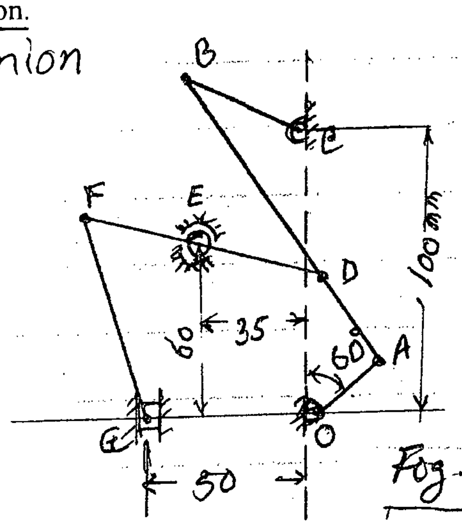
SECTION – B

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

Assume any reasonable value for any data missing.

5. In the mechanism as shown in Figure for. Q. 5, the driving crank OA is rotating anti-clockwise at 50 rpm. The length of various links and distance are as shown in the figure. Determine (a) Velocity of the slider block G (b) Acceleration of sliding of the link DF in the treenion. **(46⅔)**

trunion



OA = 30 mm
AB = 125 mm
BC = 45 mm
BA = 3 AD
FD = 100 mm
GF = 75 mm

Fig. for Ques. No 5

Contd P/4

6. (a) The length of a connecting rod of an engine is 450 mm measured between the centers and its mass is 20 kg. The center of gravity is 125 mm from the crank pin center and the crank radius is 100 mm. Determine the dynamically equivalent system keeping one mass at the small end. The frequency of oscillation of the rod, when suspended from the center of the small end is 45 vibrations per minute. **($23\frac{2}{3}$)**

(b) A punching press pierces 35 holes per minute in a plate using 10 kN-m of energy per hole during each revolution. Each piercing takes 40 percent of the time needed to make one revolution. A cast iron flywheel used with the punching machine is driven by a constant torque electric motor. The flywheel rotates at a mean speed of 210 rpm and the fluctuation of speed is not to exceed ±1 percent of the mean speed. Find (i) power of the electric motor (ii) mass of the flywheel (iii) cross-sectional dimension of the rim when the width is twice the thickness of the flywheel. Hoopstress for cast iron is 4 MPa and density = 7200 kg/m^3. **($23\frac{2}{3}$)**

7. (a) An open belt drive connects two pulleys 1.2 m and 0.5 m diameter on parallel shafts 3.6 m apart. The belt has a mass of 1 kg/m length and the maximum tension in it is not to exceed 2 kN. The 1.2 m pulley, which is the driver, runs at 200 rpm. Due to the belt slip on one of the pulleys, the velocity of the driven shaft is only 450 rpm. If the coefficient of friction between the belt and the pulley is 0.3. Find (i) Torque on each of the two shafts, (ii) Power transmitted, (iii) Power lost in friction, (iv) Efficiency of the drive. **($16\frac{2}{3}$)**

(b) Construct the profile of a cam to suit the following specific forms: **(30)**

(i) Follower will be flat faced.

(ii) The follower moves out for 80° of cam rotation with uniform acceleration and retardation. The acceleration being twice the retardation.

(iii) The follower dwells for the next 80° of cam rotation.

(iv) It moves in for the next 120° of cam rotation with uniform acceleration and retardation, the retardation being twice the acceleration.

(v) The follower dwells for the remaining period. The base circle diameter of the cam is 60 mm and the stroke of the follower is 20 mm. The line of movement of the follower passes through the cam center.

8. (a) The following data refer to two cylinder locomotive with cranks at 90°. Reciprocating mass per cylinder = 300 kg, Crank radius = 300 mm, Driving wheel diameter = 1800 mm, Distance between cylinder centerlines = 650 mm, Distance between the driving wheel center planes = 1550 mm. Determine: (i) the fraction of the reciprocating masses to be balanced if the hammer blow is not to exceed 46 kN at 96.5 km/hr. (ii) the variation in tractive effort and (iii) the maximum swaying couple. **(23)**

Contd P/5

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Contd ... Q. No. 8

(b) A twin cylinder V-engine has the cylinders set at an angle of 45°, with both piston connected to the single crank. The crank radius is 60 mm and the connecting rods are 250 mm long. The reciprocating mass per line is 2 kg and the total rotating mass is equivalent to 2.5 kg at the crank radius. A balance mass fitted opposite to the crank is equivalent to 2.75 kg at a radius of 80 mm. Determine for an engine speed of 1800 rpm, the maximum and minimum values of the primary and secondary forces due to the inertia of reciprocating and rotating masses. **($23\frac{2}{3}$)**

L-3/T-1/ME **Date : 10/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

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

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.
The questions are of equal value. Assume reasonable data if necessary.

1. (a) Write down the merits and demerits of orificemeter and venturimeter. Derive an equation of actual flow rate through an orificemeter.
(b) Air flows at the rate of 0.85 m^3/s through a horizontal round duct, which is reduced in diameter from 300 mm to 150 mm. Considering no frictional losses, find the change in pressure between inlet and outlet. The density of air is 1.22 kg/m^3.

2. (a) State the different types of energy of a flowing fluid. Give the expressions for them. Derive an equation of actual flow rate through a rectangular notch.
(b) A 90° V-notch and a rectangular notch of 350 mm width are to be used alternatively for measuring a discharge of 25 l/s of water. Find in each case the percentage error in computing the discharge that would be introduced by an error of 3 mm in observing the head over the V-notch and the rectangular notch. Take c_d for V-notch and rectangular notch as 0.60 and 0.62 respectively.

3. (a) Sketch a pitot tube and explain with example how it is used to measure the velocity of a flowing fluid.
(b) A 250 mm diameter jet of water striking a flat plate at the centre. The plate is moving away in the direction of jet with a velocity of 0.60 m/s. Calculate the force acting on the plate and the efficiency of the system.

4. (a) Explain separation in a flowing fluid with example. Deduce Bernoulli's equation from Euler equation. List all assumptions.
(b) Water is flowing through a turbine as shown in the figure. Find the power developed by the turbine. Neglect all losses.

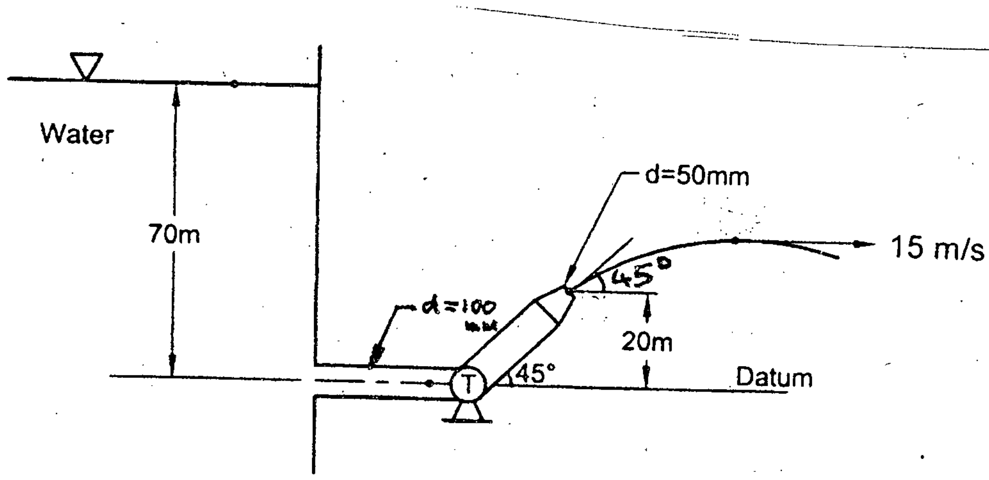

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Figure for Q. No. 4(b)

SECTION – B

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

The figures in the margin indicate full marks.

5. (a) Differentiate between gage pressure, atmospheric pressure and absolute pressure. **(5)**

(b) Determine the pressure difference in kPa between the water pipe and the oil pipe shown in Figure 5(b). What will be the pressure difference in inch of Hg? **(12)**

(c) Find the force P needed to hold the 3 m wide rectangular gate as shown in figure 5(c). **(18)**

6. (a) A disk of radius R rotates at an angular velocity Ω inside a disk shaped container filled with oil of viscosity μ, as shown in figure 6(a). Assuming a linear velocity profile and neglecting shear stress on the disk edge, derive a formula for the viscosity torque on the disk. **(18)**

(b) A wooden conical body of 1.2 m height and 1.2 m base diameter floats in water with its apex downward as shown in figure 6(b). Find the minimum weight of the cone for stable equilibrium. **(17)**

7. (a) What do you mean by (i) Incompressible flow and (ii) Irrotational flow? **(6)**

(b) What are the potential lines? What are the essential conditions for the potential lines to exist? Show that stream lines and potential lines are mutually orthogonal. **(12)**

(c) What is Rankine half-body? Show that in polar coordinate system, the equation for a Rankine half body is, **(17)**

$$r = \frac{m(\pi - \theta)}{U \sin\theta}$$

The notations have their usual meanings.

8. (a) What is circulation? What is the circulation of a free vortex? **(10)**

(b) Show that the pressure distribution on the surface of a rotating cylinder is given by, **(25)**

$$P_s = P_0 + \frac{1}{2}\rho U^2\left(1 - 4\sin^2\theta + \frac{2\Gamma \sin\theta}{\pi a U} - \frac{\Gamma^2}{4\pi^2 a^2 U^2}\right)$$

The notations have their usual meanings.

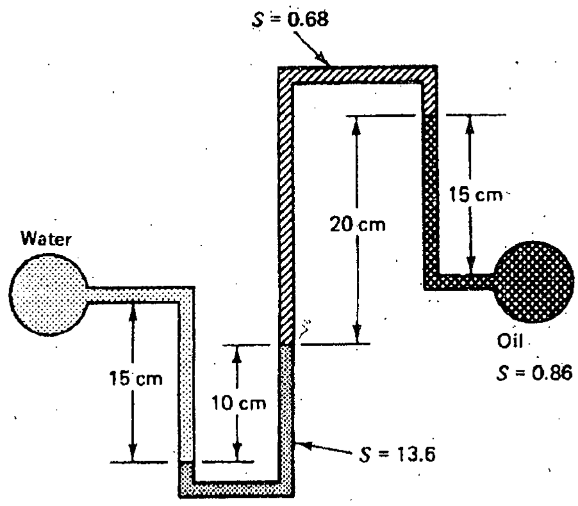


Figure for Q5b

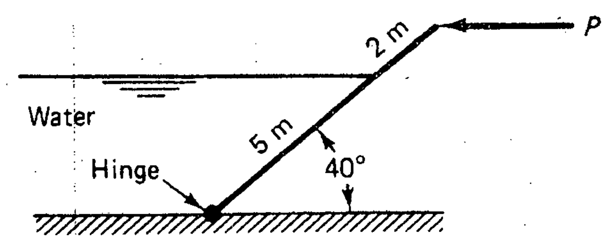


Figure for Q5c

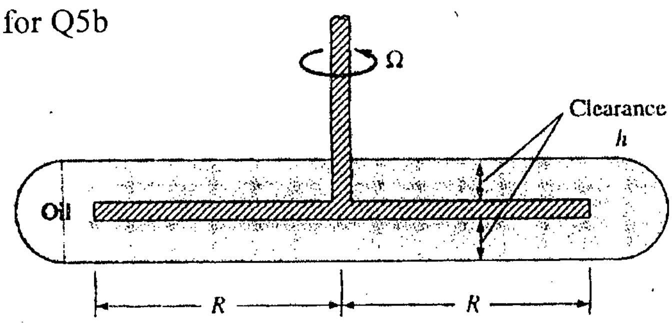


Figure for Q6a

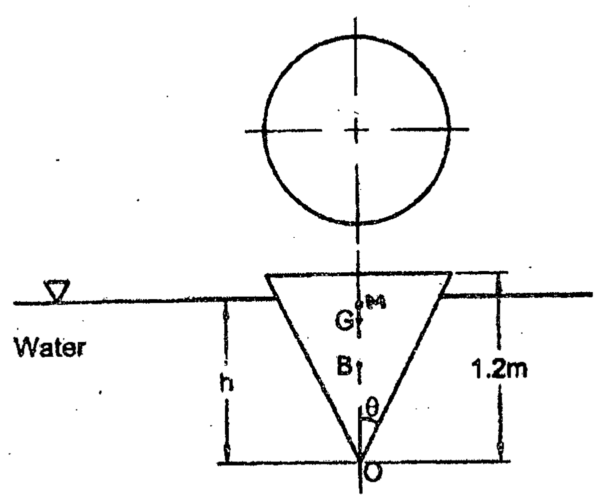


Figure for Q6b

L-3/T-1/ME **Date : 17/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **ME 341** (Machine Design I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols carry their usual meanings.

Assume reasonable value for missing data, if there is any.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Machine Design Handbook I will be supplied.

1. (a) A both ends hinged column has the cross-section shown in Fig. 1. The compressive load is not perfectly axial $\left(\frac{ec}{k^2} = 0.05\right)$. Given: L = 500 mm, E = 207 GPa, S_y = 440 MPa, compressive load = 70 kN. **(15)**
Calculate: The maximum stress developed in the column. Does it exceed column\s yield strength?
With a plot show compressive load versus mid-span's lateral deflection relation for the same column.
(b) A perfect steel column has one end clamped and the other end free. The cross-section is shown in Fig. 1. Given: S_y = 440 MPa, E = 207 GPa, l = 330 mm, safety factor = 3.5. **(20)**
(i) Find the buckling load and design load.
(ii) Plot the buckled shape of the column.
(iii) With reference to Fig. 1, find the direction of buckling.

2. (a) A spring manufacturer has produced 800 springs of stiffness 750 ± 25 kN/m. Natural spread coincides with tolerance. If only springs of stiffness 750 ± 10 kN/m are accepted, how many springs are likely to be rejected? **(10)**
(b) Statistics of a hole-shaft assembly is as below: **(25)**

$$d_s = 15.80 \pm 0.03 \text{ mm}, d_h = 15.90 \pm 0.035 \text{ mm},$$

$$\hat{\sigma}_s = 0.015 \text{ mm}, \hat{\sigma}_h = 0.02 \text{ mm}$$

(i) Find out the minimum clearance, maximum clearance and the most frequent clearance.
(ii) What % of the assembly is less than the minimum clearance?
(iii) If the basic size is 15.865 mm, find out the fundamental deviations for the hole and the shaft.

Contd P/2

3. (a) A square-thread power screw has following data: major diameter 35 mm, pitch = 5 mm, single thread, $\mu = 0.08$, external load, F = 7 kN. Ignore collar friction. **(15)**

   (i) Find out the torque required, efficiency and mechanical advantage during lifting the load.

   (ii) Is the screw self-locked during lowering the load?

   (b) Fig. 3 shows a bolted connection for joining BS 180 CI member (E_m = 80 GPa) by 6 bolts (M 16 X 2, 90 mm long, property class 8.8 coarse pitch lubricated). The preload, F_i = 55 kN per bolt. **(20)**

   (i) Find out the stiffness k_b, k_m, joint constant C, and torque T_i.

   (ii) With a plot show how F_b and F_m change with external load P. Calculate P if F_b = 70 kN per bolt and safety factor = 1.

   (iii) Calculate per bolt the value of F_b when the joint starts to open.

   (iv) What is the best way to increase the separating force P_0?

4. (a) Fig. 4(a) shows a cantilever supported by a bolted joint. Major diameter (nominal) of the bolt is 20 mm. **(20)**

   (i) List all possible modes of failure of the bolted joint.

   (ii) Calculate: the maximum shear stress on the bolt and the maximum bearing stress on the member.

   (b) Fig. 4(b) shows a welded joint subjected to a torque, T. The allowable shear stress is 140 MPa. Find the maximum torque that can be applied. **(15)**
   Which point of the weldment is the most critically stressed?

SECTION – B

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

5. (a) In a deep groove ball bearing (as shown in Fig. for Q. No. 5(a)) the diameter of the steel sphere is 10 mm. If the radius of curvature of the groove is 5 mm larger than the radius of the sphere, and the force (F) acting at the contact surface is 10 N, calculate the maximum contact pressure. Also, calculate the three principal stresses at the point of contact. Consider, the modulus of elasticity, E = 207 GPa, and the Poisson's ratio 0.3 for both the sphere and groove material. **(17)**

   (b) A lever subjected to a downward static force of 1.8 kN is keyed to a 25 mm round bar as shown in the Fig. for Q. No. 5(b). If the material of the bar is BS825M40 steel with S_y = 1020 MPa, **(18)**

   (i) Calculate the Von Mises stress at point P of the bar.

   (ii) What are the safety factors maintained in the design according to the maximum shear stress theory and the distortion energy theory.

6. A machine part of uniform thickness t = b/5 is shaped as shown in Fig. for Q. NO. 6. The part is made of BS080M50 cold drawn steel material. The design is to be for indefinite life with the following two load cases. **(35)**

   (i) Fluctuating load of 0 to 10 kN.

   (ii) Completely reserved load of –5 to +5 kN.

   Determine the dimension (b) of the part considering a design factor of 1.4 based on the Goodman equation. Also, choose 95% reliability for your design.

7. (a) For the cantilever bar as shown in Fig. for Q. No. 7(a), the bending and torsional load are 2 kN and 50 N-m. If the maximum allowable shear stress at point A is 150 MPa, then calculate: **(18)**

   (i) The minimum diameter of the shaft.

   (ii) The three principal stresses at point A.

   (iii) The three principal strains at point A.

   Assume, the modulus of elasticity, E = 207 GPa and the Poisson's ratio 0.3 for the bar material.

   (b) A sonic crack detector is used to detect cracks on the outer surface of a gas cylinder. If the minimum depth of crack that can be detected by the instrument is 2 mm, what would be the maximum allowable gas pressure in the cylinder with a design factor of 2? Consider, the inner and outer diameter of the cylinder are 300 mm and 400 mm, respectively. Also, for the cylinder material, S_y = 1515 MPa, K_{IC} = 60 MPa $m^{1/2}$. **(17)**

8. (a) For the loading and geometric configuration shown in Fig. for Q. No. 5(b), find the deflection of the bar at the mid-point along the length of the bar. Consider the bar material as BS825M40 steel with S_y = 1020 MPa, E = 207 GPa, Poisson's ratio = 0.3. Use Castigliano's theorem and the method of superposition in your calculation. **(20)**

   (b) A cylindrical pressure vessel is made of BS403SI7 stainless steel (S_y = 250 MPa, S_{ut} = 430 MPa) and it is subjected to an internal pressure of 30 MPa. If the outside diameter of the cylinder is 200 mm, find the minimum wall thickness which will ensure a design safety factor of 2 according to the maximum shear stress theory. Also, calculate the longitudinal stress at the end of the cylinder. **(15)**

ME341

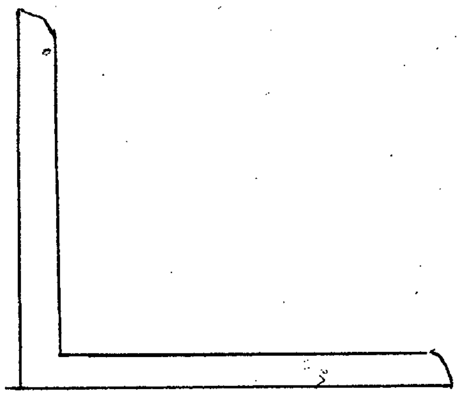


FIG. 1

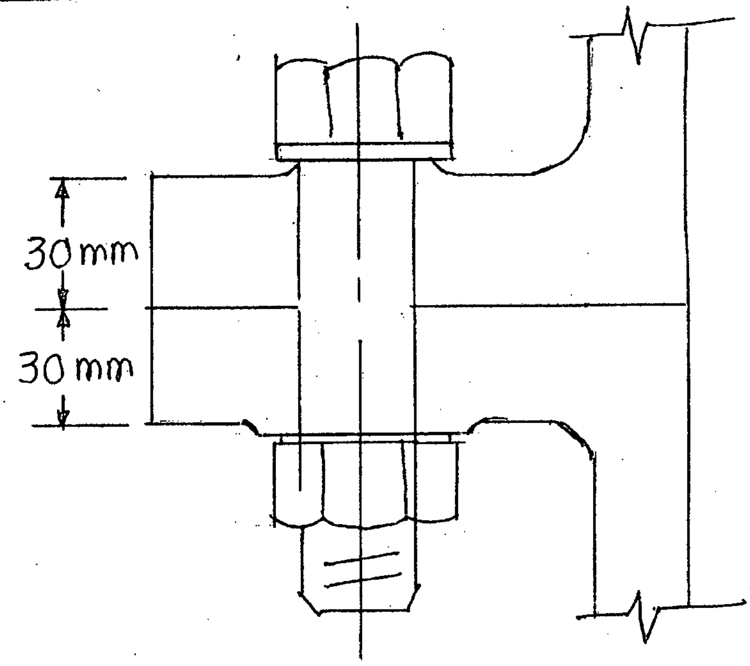


FIG. 3

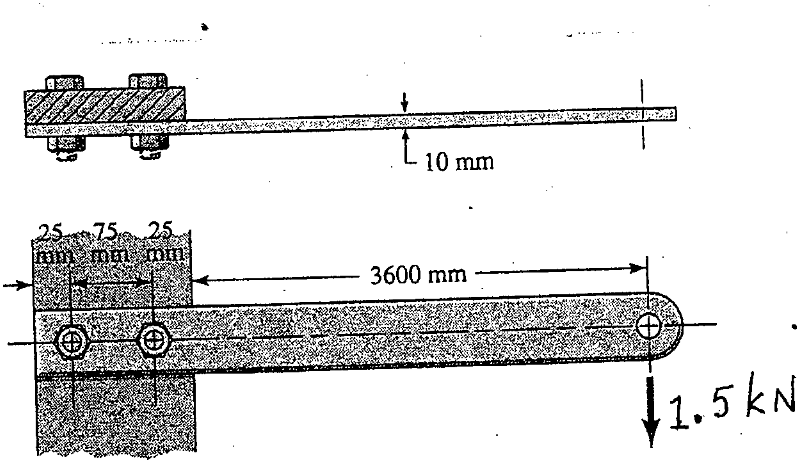


FIG. 4a

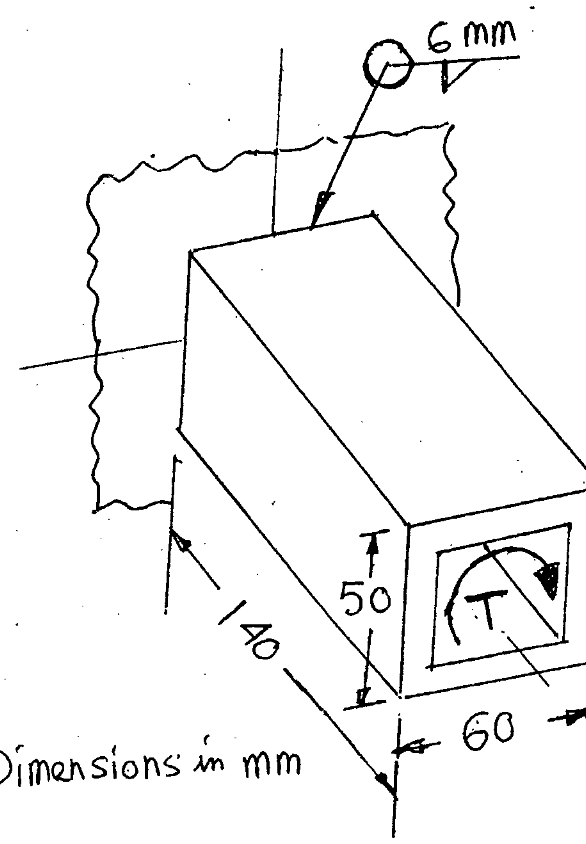


FIG. 4b

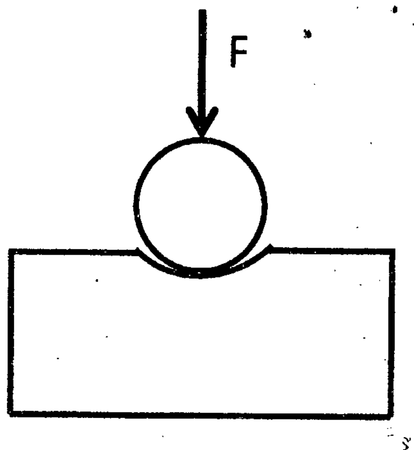


Fig. for Q. No. 5(a)

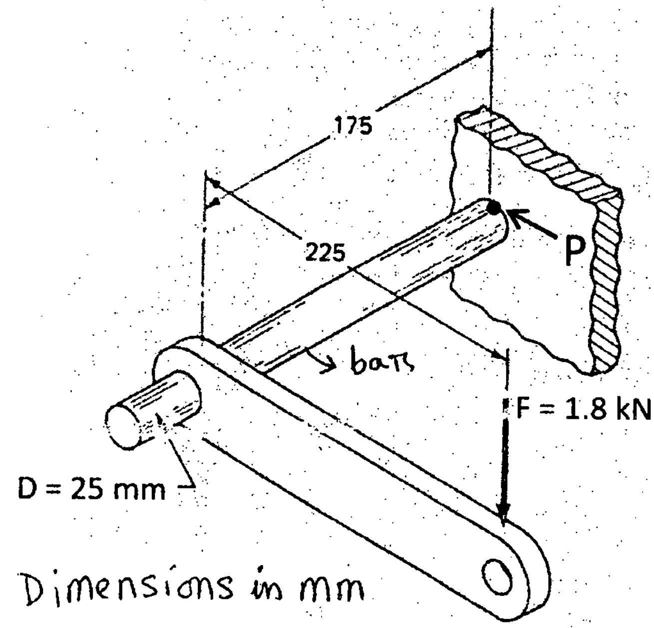


Fig. for Q. No. 5(b)

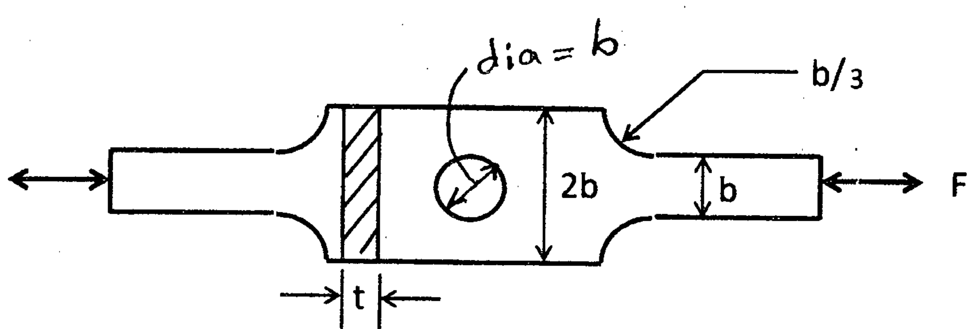


Fig. for Q. No. 6

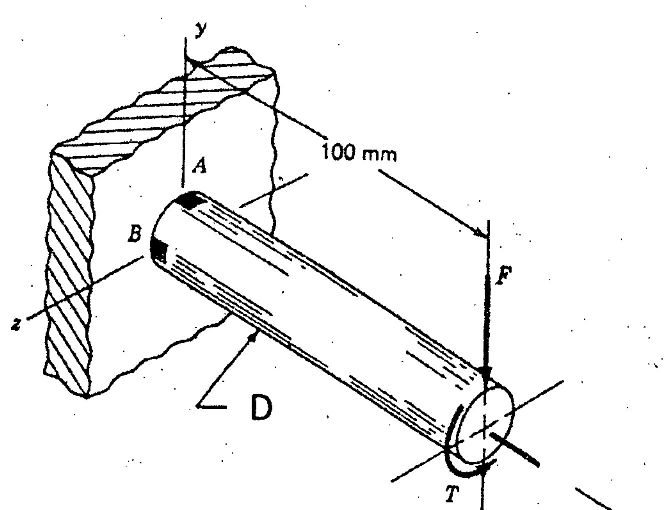


Fig. for Q. No. 7(a)

L-3/T-1/ME **Date : 24/05/2014**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **ME 301** (Conduction and Radiation Heat Transfer)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meaning.

Assume any missing data with reasonable accuracy.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Heisler charts have been supplied.

1. (a) Consider two stainless steel blocks [k = 20 W/m.°C], each having a thickness of 1 cm, length of 8 cm, and width of 6 cm, that are pressed together with a pressure of 20 atm. The surface have a roughness of about 0.76 μm. The outside surfaces of the blocks are at 120°C and 70°C. Given that the contact conductance, h_c = 10,000 W/m^2.°C. Calculate **(18)**

   (i) the heat flow rate across the blocks

   (ii) the temperature drop at the interface

   (b) A thick-walled tube of stainless steel [18% Cr, 8% Ni, k = 19 W/m.°C] with 2 cm inner diameter (ID) and 4 cm outer diameter (OD) is covered with a 3-cm layer of asbestos insulation [k = 0.2 W/m.°C]. If the inside wall temperature of the pipe is maintained at 600 °C, calculate the heat loss per meter of length. Also calculate the tube-insulation interface temperature. **(17)**

2. Derive the expression for the temperature distribution and heat loss from an extended surface (fin) of uniform cross section area, where the tip of the surface is insulated and hence solve the following problem: **(35)**

   An aluminum fin [k = 200 W/m.°C] 3.0 mm thick and 7.5 cm long protrudes from a wall. The base is maintained at 300°C, and the ambient temperature is 50°C with h = 10 W/m.°C, calculate the heat loss from the fin per unit depth of material.

3. (a) When a thermocouple is moved from one medium to another medium at a different temperature, the thermocouple must be given sufficient time to come to thermal equilibrium with the new conditions before a reading is taken. Consider a 0.10 cm diameter copper thermocouple wire originally at 150°C. Determine the temperature response when this wire is suddenly immersed in (i) water at 40°C (h = 80 W/m^{2}k) and (ii) air at 40°C (h = 10 W/m^{2}k). You have to calculate the time required for the instantaneous temperature difference to reach 1.0% of the initial temperature difference. Given that for copper; k = 391 W/mk, c = 383 J/kgK, ρ = 8930 kg/m^3. **(18)**

Contd P/2

ME 301

Contd ... Q. No. 3

(b) A steel plate [$\alpha = 1.2 \times 10^{-5}$ m^2/s, k = 43 W/m.°C, c_p = 465 J/kg.°C and ρ = 7833 kg/m^3] of thickness 10 cm, initially at a uniform temperature of 240°C, is suddenly immersed in an oil bath at 40°C. The convection heat transfer coefficient between the fluid and the surface is 600 W/m^2.°C. **(17)**

(i) How long will it take for the center-plane to cool to 100°C?

(ii) What is the temperature at a depth 3 cm from the outer surface when the center-plane is cooled to 100°C?

(iii) Calculate the energy removed from the plate during this time.

4. (a) Derive the expression of average temperature for a solid sphere, where R is the radius of the sphere, T(r) is the variable temperature inside the solid and r is the variable radius. **(10)**

(b) Consider a slab of thickness 0.15 m with a thermal conductivity k = 40 W/m.°C in which energy is generated at a constant rate of 10^6 W/m^3. The boundary surface at x = 0 is insulated, and the one at x = 0.15 m is subjected to convection with a heat transfer coefficient of 300 W/m^2.°C into an ambient at a temperature of 250°C. The slab is subdivided into five equal subregions, as illustrated in Fig. 4(b). Develop the finite-difference equations for the problem. **(25)**

SECTION – B

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

5. (a) With necessary diagram discuss briefly the differences among black body, gray body and real surface regarding emission, absorption and reflection of radiation. **(10)**

(b) The diameter of the sun is 1.39×10^9 m and the distance between the sun and the earth is 1.496×10^{11} m. Determine the solid angle subtended by the sun with respect to the earth. Consider conditions for a day in which the intensity of the direct solar radiation is $I_{dir} = 2.10 \times 10^7$ W/m^2.sr. What is the direct solar irradiation at the earth's surface when the direct radiation is incident at zenith angle 30°? **(10)**

(c) The spectral emissivity function of an opaque surface at 1000 K is approximated as **(15)**

$$\epsilon_\lambda = \begin{cases} \epsilon_1 = 0.4 & 0 \le \lambda < 2\ \mu m \\ \epsilon_2 = 0.7 & 2\mu m \le \lambda < 6\ \mu m \\ \epsilon_3 = 0.3 & 6\ \mu m \le \lambda < \infty \end{cases}$$

Determine the average emissivity of the surface and the rate of radiation emission from the surface in W/m^2.

Contd P/3

ME 301

6. (a) Determine the shape factor, F_{1-2} between the rectangular surfaces shown in Figure for Q. No. 6(a). **(25)**

(b) By using the crossed-string method determine the view factors F_{1-2} and F_{2-1} for the very long ducts shown in Figure for Q. No. 6(b). **(10)**

7. (a) A furnace is of cylindrical shape with a diameter of 1.2 m and a length of 1.2 m. The top surface has an emissivity of 0.70 and is maintained at 500 K. The bottom surface has an emissivity of 0.50 and is maintained at 650 K. The side surface has an emissivity of 1.0. Heat is supplied from the base surface at a net rate of 1400 W. (as shown in Figure for Q. No. 7(a)). Determine the temperature of the side surface and the net rates of heat transfer between the top and bottom surfaces. **(20)**

(b) Two thin radiation shields with emissivities of $\in_3 = 0.10$ and $\in_4 = 0.15$ on both sides are placed between two very large plates, which are maintained at uniform temperatures $T_1 = 600$ K and $T_2 = 300$ K and have emissivities $\in_1 = 0.6$ and $\in_2 = 0.7$, respectively (as shown in Fig for Q. No. 7(b)). Determine the net rates of radiation heat transfer between the two plates with and without the shields per unit surface area of the plates, and the temperatures of the radiation shields in steady operation. **(15)**

8. (a) What is solar radiation? Give a sketch of spectral distribution of solar radiation on earth surface and just outside the atmosphere and discuss its characteristics. **(15)**

(b) Consider a steam pipe of length L, inner radius r_1, outer radius r_2, and constant thermal conductivity K. Steam flows inside the pipe at an average temperature of T_i with a convection heat transfer coefficient of h_i. The outer surface of the pipe is exposed to convection to the surrounding air at a temperature of T_0 with a heat transfer coefficient of h_0. Assuming steady one-dimensional heat conduction through the pipe, (i) express the differential equation and the boundary conditions for heat conduction through the pipe material, (ii) obtain a relation for the variation of temperature in the pipe material by solving the differential equation. **(20)**

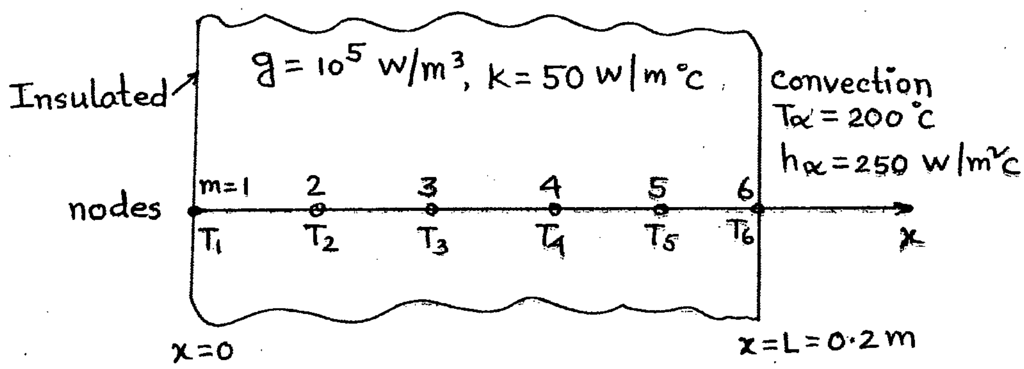


Fig. 4(b)

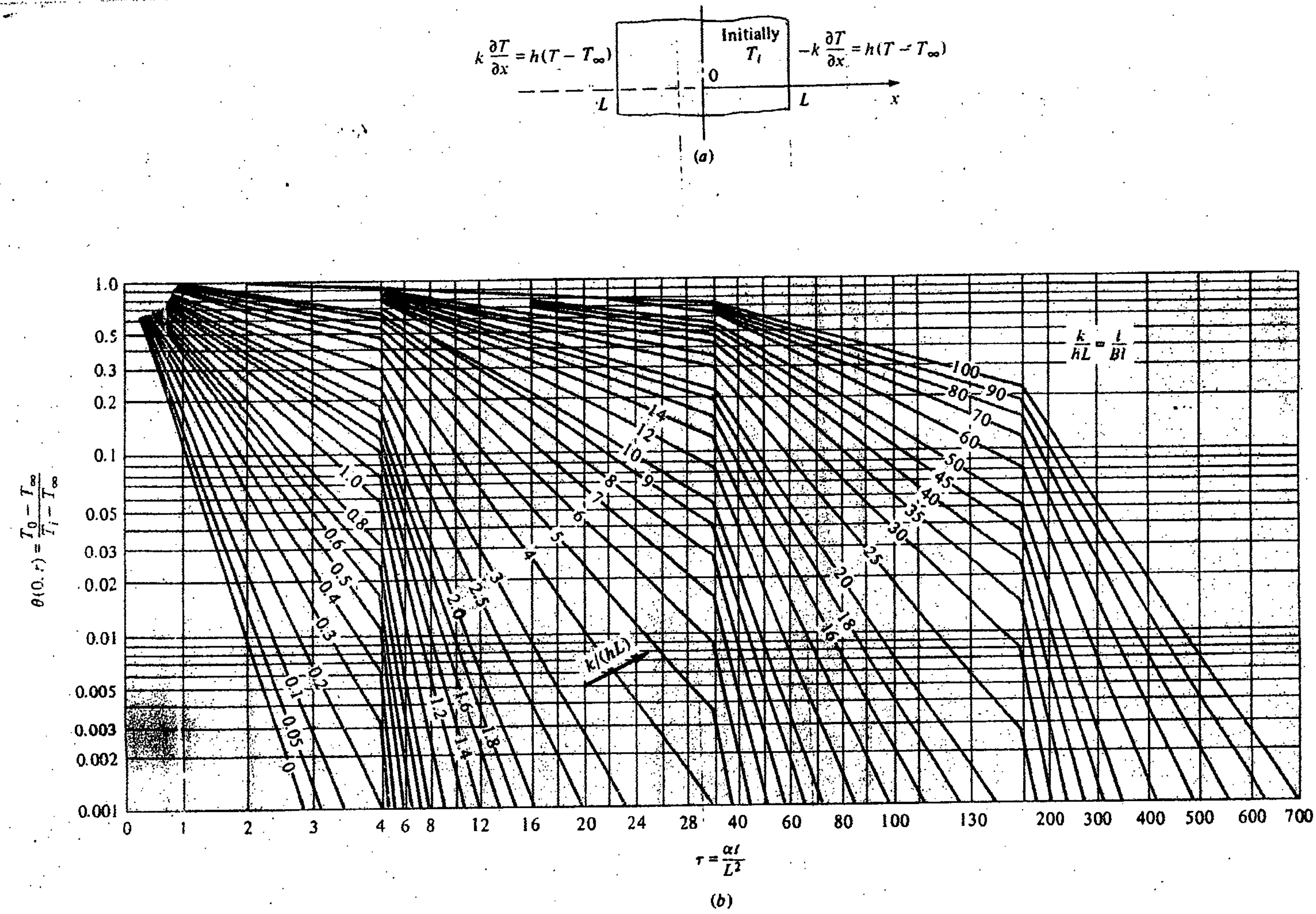


FIGURE
Transient temperature chart for a slab of thickness $2L$ subjected to convection at both boundary surfaces. (From Heisler) (a) Geometry, coordinates and boundary conditions for the physical problem; (b) Dimensionless temperature $\theta(0, \tau)$ at the center plane, $x = 0$;

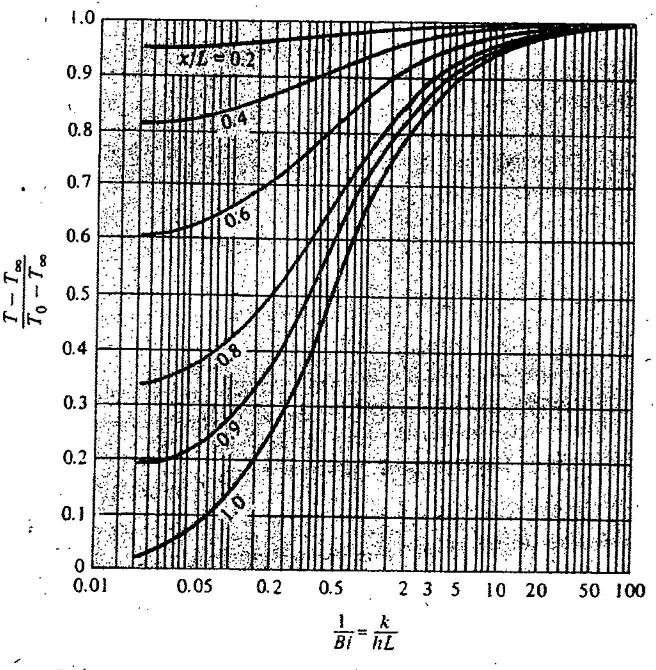


FIGURE
(c) Position correction for use with part (b).

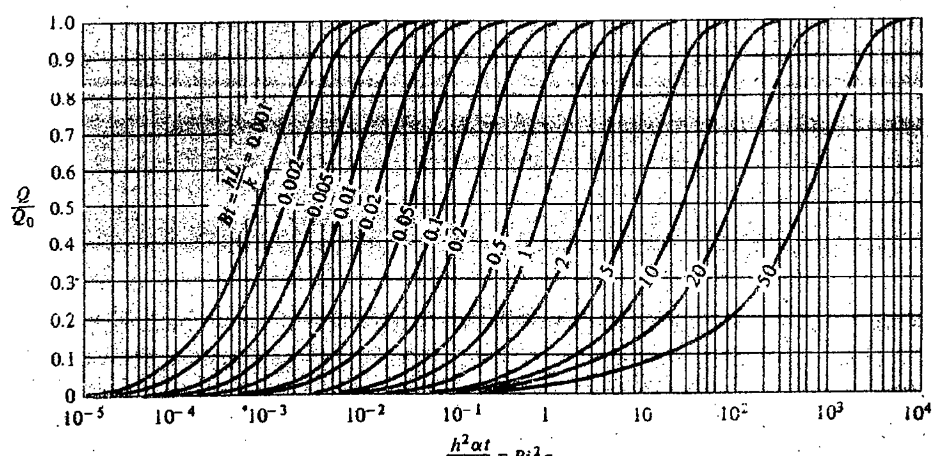


FIGURE
Dimensionless heat transferred Q/Q_0 for a slab of thickness $2L$. (From Gröber, Erk and Grigull).

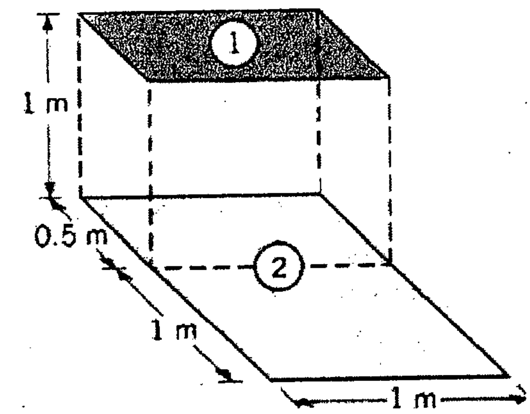


Figure for the Q. No. 6(a)

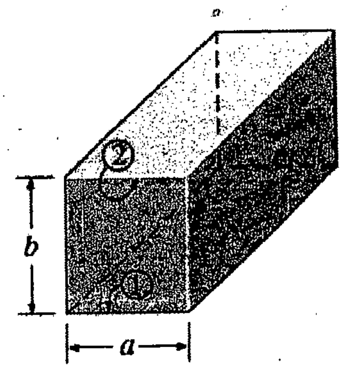


Figure for the Q. No. 6(b)

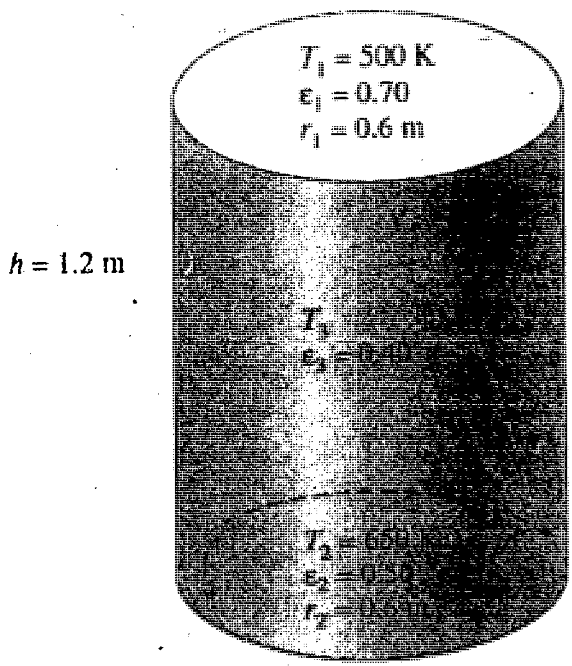


Figure for the Q. No. 7(a)

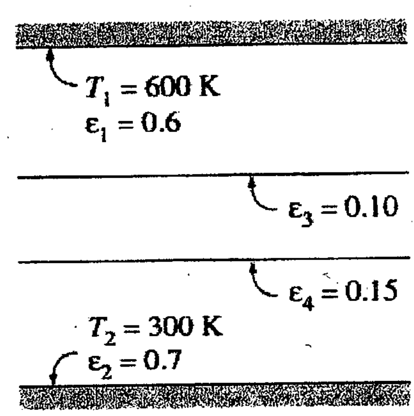
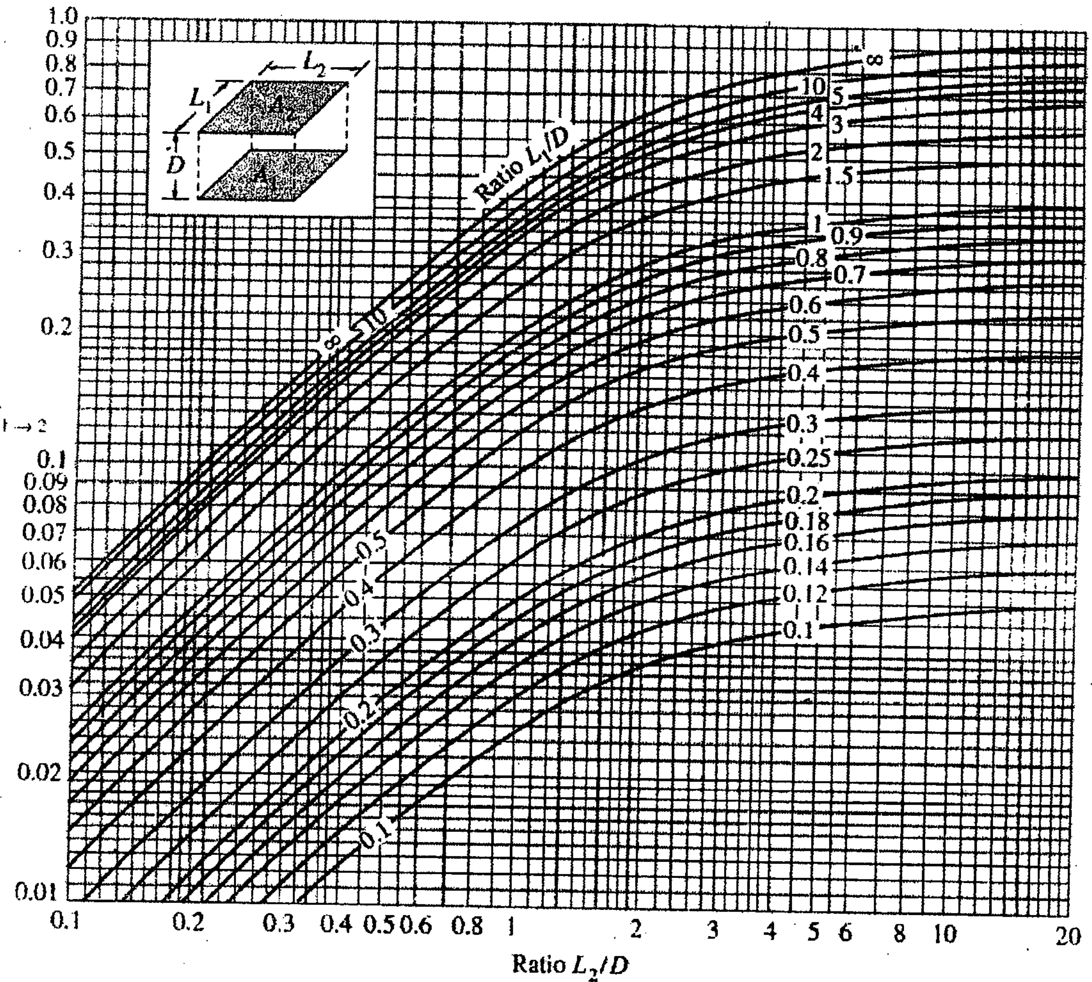


Figure for the Q. No. 7(b)

TABLE [illegible]

Blackbody radiation functions f_λ

λT, μm · K	f_λ	λT, μm · K	f_λ
200	0.000000	6200	0.754140
400	0.000000	6400	0.769234
600	0.000000	6600	0.783199
800	0.000016	6800	0.796129
1000	0.000321	7000	0.808109
1200	0.002134	7200	0.819217
1400	0.007790	7400	0.829527
1600	0.019718	7600	0.839102
1800	0.039341	7800	0.848005
2000	0.066728	8000	0.856288
2200	0.100888	8500	0.874608
2400	0.140256	9000	0.890029
2600	0.183120	9500	0.903085
2800	0.227897	10,000	0.914199
3000	0.273232	10,500	0.923710
3200	0.318102	11,000	0.931890
3400	0.361735	11,500	0.939959
3600	0.403607	12,000	0.945098
3800	0.443382	13,000	0.955139
4000	0.480877	14,000	0.962898
4200	0.516014	15,000	0.969981
4400	0.548796	16,000	0.973814
4600	0.579280	18,000	0.980860
4800	0.607559	20,000	0.985602
5000	0.633747	25,000	0.992215
5200	0.658970	30,000	0.995340
5400	0.680360	40,000	0.997967
5600	0.701046	50,000	0.998953
5800	0.720158	75,000	0.999713
6000	0.737818	100,000	0.999905



Graph 1: View factor between two aligned parallel rectangles of equal size.

L-3/T-1/ME Date : 31/05/2014

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2012-2013

Sub : **ME 361** (Instrumentations 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**.

1. (a) What do you mean by beat frequency and heterodyning? Describe with sketches and examples. **(8)**

   (b) Mention some merits, demerits, and applications of a capacitive transducer. **(9)**

   (c) Briefly explain the working principle of LVDT with suitable diagrams and mention its advantages. **(10)**

   (d) Describe time-displacement relations for damped motion with sketches. **(8)**

2. (a) What are the differences among absolute, gauge, and barometric pressure? Describe with sketches. **(7)**

   (b) With a sketch describe the working principle of a dead weight tester for static calibration. What might be sources of errors in such a device? **(9)**

   (c) With sketches describe the elastic elements used as pressure sensors. **(8)**

   (d) What do you mean by capacitance pressure transducer? What are its drawbacks? **(11)**

3. (a) Give sketches of orifice and flow nozzle. Describe their competitive advantages and application. **(10)**

   (b) Describe the working principle of a pitot tube and mention its advantages. **(8)**

   (c) What do you mean by PIV? Describe with sketches and mention its specific merits. **(10)**

   (d) Write short note on 'temperature measurement on a rotary surface. **(7)**

4. (a) Mention basic characteristics of the following temperature measuring elements and devices **(10)**

   (i) thermocouple (ii) Liquid in glass thermometer (iii) RTD (iv) semiconductor junction (v) thermistor.

   (b) With sketches describe the working principle of different types of heat flux gauges used in industrial practice. **(8)**

   (c) What do you mean by metallic resistance strain gauges? Derive an expression of gauge factor and explain its physical meaning. **(7)**

   (d) What do you mean by data logger? With a rough sketch describe its working principle. **(10)**

Contd P/2

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SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Make reasonable assumptions in case of any missing data.

5\. (a) Find out V_{out} in terms of C, R and V_{in} for the following integrator circuit. What will the shape of V_{out} be if the signal V_{in} is a square wave? Draw the input and output wave form. **(8)**

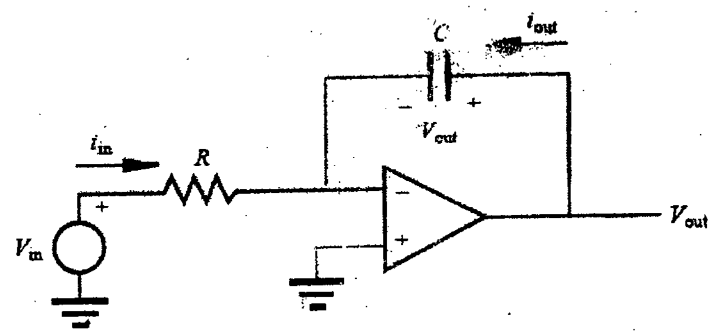

Fig. Ques. 5(a)

(b) Write short note on "Comparator" and "Sample-and-Hold Circuit". **(8)**

(c) A square wave that goes between +/– V_o with period T is applied to the following RC circuit. Complete the following graphs: **(12)**

$V_{CAP}(t)$ for:

(1) RC ≈ T

(2) RC << T

(3) RC >> T

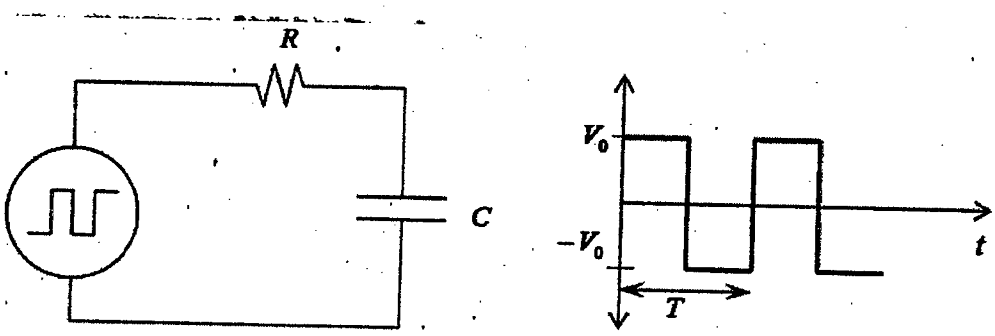

Fig. Ques. 5(c)

(d) How an actual op amp deviates in characteristics from an ideal op amp? Discuss. **(7)**

6\. (a) Determine the Transfer Function (TF) of a general second order system. Hence, deduce the expression of amplitude ratio and phase angle. **(10)**

(b) A simple glass bulb thermometer is an example of a first-order system where the input is the surrounding temperature (T_{in}) and the output is the temperature of the liquid inside the bulb (T_{out}), which expands to provide a reading on a scale. Using basic heat transfer principles, where the rate of convective heat transfer in equals the rate of change of internal energy of the fluid, derive the system equation and write it in standard form. Identify the time constant. The parameters in your equation should include the fluid mass (m) and specific heat (c), and the bulb external area (A) and heat transfer coefficient (h). **(9)**

Contd P/3

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Contd ... Q. No. 6

(c) Write short note on the following terms: **(9)**

(i) Zeroth Order System

(ii) Rise time, Settling time, and Slew rate

(iii) Amplitude response, Frequency response, and Phase response.

(d) Prove that the settling time of a first order system is given by 4*time constant. Given that the error, $e_m = X_\infty - X(t) = (X_\infty - X_o)e^{-t/\pi}$, where the symbols have their usual meaning. **(7)**

7. (a) Discuss briefly the different steps involved in an ADC process. **(8)**

(b) Given a 10-bit A/D converter operating over a voltage range from 0 V to 5 V, how much does the input voltage have to change in order to be detectable? **(5)**

(c) Explain the working principle of a "Dual Slope Integrating ADC". **(7)**

(d) Write short note on Shannon's sampling theorem. **(5)**

(e) How a npn transistor can be used as a switch? Discuss with necessary circuit diagram. **(5)**

(f) Discuss the phenomenon of inductive kick. How diodes are used to eliminate any danger associated with inductive kick? **(5)**

8. (a) Discuss the working principle of a microphone of your choice like condenser type, electrodynamic type etc. **(10)**

(b) Describe with proper sketches the working principle of a seismic instrument. **(10)**

(c) Why are capacitors often used to eliminate noise in an electrical circuit? Discuss with the charging and discharging diagram of a capacitor. **(5)**

(d) Assume that the red LED of the following circuit turns on with a forward voltage of 2.0 V. **(10)**

(i) What is the minimum value of R_L for which some current still flows through the LED?

(ii) Assuming that R_L is above that minimum (found in i) what is the voltage across R_L? How does it change as R_L is increased above that minimum value?

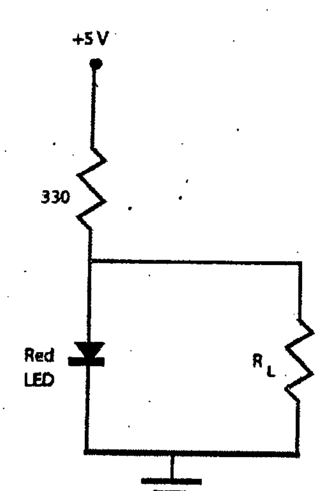

Fig. Ques. 8(d)
