L-3/T-2/NAME **Date : 20/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **NAME 347** (Design of Special Ships)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Assume suitable values for missing data, if any.

1. (a) Provide the profile drawing of a typical oil tanker and discuss the important design features. **(15)**

(b) A very large crude carrier (VLCC) is to be designed for a total deadweight of 175,000 tonne. Calculate the length, breadth, depth, block coefficient and displacement if the vessel draft is 19 m and the speed is 17 knots. **(20)**

2. (a) Write a short note on Aircraft carrier describing important design features. **(25)**

(b) Draw the flight deck and transverse section of a typical aircraft carrier. **(10)**

3. A guided missile destroyer has a displacement of 6500 tonf made up of as follows: **(35)**

Hull	= 2400 tonf
Machinery	= 1600 tonf
Armament	= 700 tonf
Fuel	= 1300 tonf
Equipment	= 500 tonf

The vessel speed is 30 knots and SHP 60,000 at full power. The endurance is 5000 miles at 18 knots. A new design is to be similar but is required to carry 100 tonf extra in the form of armament and a full power speed of 28 knots. The endurance is to be 5500 miles at 20 knots.

Estimate the displacement and group weights of the new design.

The following assumptions are to be made:

(i) SHP varies as $V^{2.8}$ at full power and as V^3 at 18-20 knots.

(ii) Saving of 5% are expected on both hull and machinery groups due to advances in design and material.

(iii) Full consumption rate is reduced by 3%.

4. (a) The principle particulars of a nuclear attack submarine is given below: **(25)**

Length = 250 ft.

Diameter of hull (maximum) = 30 ft.

Displacement (submerged) = 3250 tons.

Contd P/2

NAME 345

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

Calculate,

(i) Wetted surface area of bare hull and of appendages.

(ii) The effective horsepower at 30 knots speed and also the shaft horsepower if propulsive coefficient is 0.7.

Given:

The wetted surface area of the appendages is 0.18 times of that of the bare hull. The average viscous drag coefficient of the appendages is 2.0 times of that of the bare hull.

Roughness (correlation) allowance = 0.0002

Kinematic viscosity of water = 1.279×10^{-5} ft^2/sec.

Density of water = 35 ft^3/ton.

(b) Discuss the major differences between a submarine and a surface slip. **(10)**

SECTION-B

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

5. (a) Draw a figure showing the operation of a stern trawler. Describe the classification of Distant Water Trawlers. **(35)**

6. Calculate the length, displacement, depth, breadth, prismatic coefficient and block coefficient of a Dock Tug having engine power 1000 KW. Assume suitable values for missing data, if any. **(35)**

7. Describe the cargo landing systems used in Ro Ro ship. Draw the sketch of a slewing ramp and describe the operational procedure. **(35)**

8. A container ship of capacity 1550 contains of size 6.05m × 2.43m × 2.43m (1150 containers in holds and 400 containers on deck) has **(35)**

Service draught = 10 m

Service speed = 22 knots

Assume the containers are 7 high in each cell with 10 cells across the ship and Engine room length = 20% of ship length between perpendicular in meter – 10.71 meter. Calculate the length, breadth, depth, block coefficient and displacement of the Container ship.

Also draw a typical GA plan of the Container ship.

L-3/T-2/NAME **Date : 20/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **NAME 363** (Computational Fluid Dynamics)

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) Derive second order accurate forward and backward finite different formulae for $\frac{\partial f}{\partial x}$. **(15)**

   (b) Discuss how you can solve the momentum equation using SIMPLE algorithm. **(20)**

2. (a) What are the differences between structured and unstructured grid? Transform the following equation from the physical space to computation space. **(15)**

$$\frac{\partial u}{\partial x} + \alpha \frac{\partial u}{\partial y} = 0.$$

   (b) Derive the shape functions $N_i(x, y)$ for triangular element and hence show that $\sum_{i=1}^{3} N_i(x, y) = 1$. **(20)**

3. (a) Find the functional of the following boundary value problem. **(15)**

   $\frac{d^2y}{dx^2} = f(x)$ with $y(a) = y(b) = 0$.

   (b) Derive the Euler-Lagrange equation for the necessary condition of a functional to have an extreme value. **(20)**

4. Solve the two dimensional boundary value problem **(35)**

   $\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} = 0$ with u = 0 on the boundary of the square $(0 < x \le 1,\ 0 < y \le 1)$ by finite element method. The half of the region is to be discretized into 4 triangular elements.

Contd P/2

SECTION-B

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

Symbols have their usual meaning. Reasonable value can be assumed for any missing data.

5. Explain source panel method and derive its formulation for calculating velocity and pressure distribution over the surface of a body of arbitrary shape. **(35)**

6. (a) According to conservation laws of fluid flow prove that: **(15)**

$$\frac{\partial(\rho\phi)}{\partial t} + div(\rho\phi\bar{u}) = \rho\frac{D\phi}{Dt}$$

(b) Explain Finite Volume Method for solving one-dimensional steady state diffusion problem. How can you extend it to two-dimensional problem? **(20)**

7. (a) Describe finite volume method for solving steady one-dimensional convection and diffusion problem using central differencing scheme. **(20)**

(b) How can you overcome the limitation of the central differencing scheme for above mentioned problem [7(a)] using the upwind differencing scheme? **(15)**

8. (a) How can you assess the hybrid differencing scheme in CFD? **(15)**

(b) A property ϕ is transported by means of convection and diffusion through the one dimensional domain sketched in Fig. for Q.N. 8(b). Calculate the distribution of ϕ as a function of x for u = 0.25 m/s. Use five equally spaced cells and the central differencing scheme for convection and diffusion. [$\rho = 1.0$ kg/m^3, $\Gamma = 0.1$ kg/m/s]. **(20)**

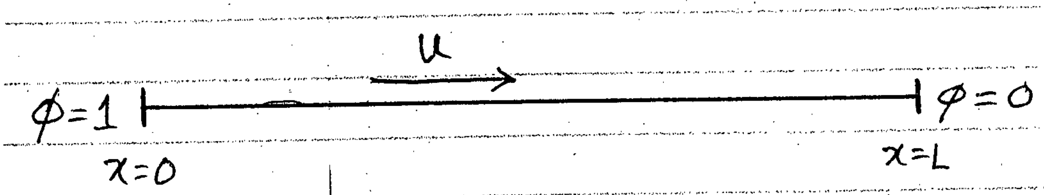

Fig. for Q.N. 8(b)

L-3/T-2/NAME **Date : 16/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **NAME 319** (Theory of Machines)

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**.

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

1. (a) What is instantaneous center of rotation in kinematics of machines? State the major properties of instantaneous center. **(12)**

(b) The mechanism of a wrapping machine, as shown in figure for Q. No. 1(b) has the following dimensions: **(23)**

O_1A = 100 mm, AC = 700 mm, BC = 200 mm.
O_3C = 200 mm, O_2E = 400 mm, O_2D = 200 mm
and BD = 150 mm.

The crank O_1A rotates at a uniform speed of 100 rad/s. Find the velocity of the point E of the bell crank lever by instantaneous center method.

2. (a) What do you mean by mobility of mechanism? Determine the degrees of freedom of the mechanism shown in figure for Q. No. 2(a). **(15)**

(b) In a crank and slotted lever quick return motion mechanism, the distance between the fixed centers O and C is 200 mm. The driving crank CP is 75 mm long. The pin Q on the slotted lever, 360 mm from the fulcrum O, is connected by a link QR 100 mm long, to a pin R on the ram. The line of stroke of R is perpendicular to OC and intersects OC produced at a point 150 mm from C. Draw the skeleton diagram of the mechanism and determine **(20)**

(i) The length of stroke
(ii) The ratio of times taken on the cutting and return strokes.

3. (a) Derive an expression for the length of a Cross Belt Drive and show that the length of belt required remains constant if sum of the radii of the two pulleys be constant. **(17)**

(b) The following data refer to an open belt drive: Diameter of larger pulley = 400 mm Diameter of smaller pulley = 250 mm, distance between two pulley = 2 m, coefficient of friction between smaller pulley surface and belt = 0.4, maximum tension when the belt is on the point of slipping = 1200 N. Find the power transmitted at speed of 10 m/s. It is desired to increase the power. Which of the following two methods will you select? Justify. **(18)**

(i) Increasing the initial tension in the belt by 10%
(ii) Increasing coefficient of friction between the smaller pulley surface and belt by 10% by the application of suitable dressing on the belt.

4. (a) Derive an expression for the magnitude and direction of coriolis component of acceleration. **(15)**

Contd P/2

NAME 319

Contd... Q. No. 4

(b) Figure for Q. No. 4(b) shows the structure of Whitworth quick return mechanism used in reciprocating machine tools. The various dimensions of the tool are as follows: **(20)**

OQ = 100 mm, OP = 200mm,

RQ = 150 mm and RS = 500 mm.

The crank OP makes an angle of 60° with the vertical. Determine the velocity of the slider S (cutting tool) when the crank rotates at 120 rpm clockwise. Find also the angular velocity of the link RS and the velocity of the sliding block T on the slotted lever QT.

SECTION-B

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

5. (a) Differentiate between impulse and impulsive force with examples. **(5)**

(b) Deduce the equation of energy lost by friction clust during engagement. **(20)**

(c) A haulage rope winds on a drum of radius 500 mm, the free end being attached to a truck. The truck has a mass of 500 kg and is initially at rest. The drum is equivalent to a mass of 1250 kg with radius of gyration 450 mm. The rim speed of the drum is 0.75 m/s before the rope tightens. By considering the change in linear momentum of the truck and in the angular momentum of the drum, find the speed of the truck when the motion becomes steady. Find also the energy lost to the system. **(10)**

6. (a) Explain mathematically how kinetic energy is lost during elastic impact between two bodies. **(18)**

(b) A loaded railway wagon has a mass of 15 tones and moves along a level track at 20 km/h. It over takes and collides with an empty wagon of mass 5 tonnes, which is moving along the same track at 12 km/h. If each wagon is filled with two buffer springs of stiffness 1000 KN/m, find the maximum deflection of each spring during impact and the speeds of the wagons immediately after impact ends. **(17)**

If the coefficient of restitution for the buffer springs is 0.5, how would the final speeds be affected and what amount of energy will be dissipated during impact?

7. (a) Categorize the "laws of friction" on the following basis: **(18)**

   (i) Static friction
   (ii) Dynamic friction
   (iii) Solid friction
   (iv) Fluid friction

(b) Derive mathematically the torque required to lower the load by a screw jack. **(17)**

8. (a) Define cycloidal teeth. Describe with figure the construction of two mating cycloidal teeth. **(10)**

(b) Determine the length of path of contact and length of arc of contact for a pinion driving the wheel. **(17)**

(c) Compare between involutes and cycloidal gears. **(8)**

Cont... P/3

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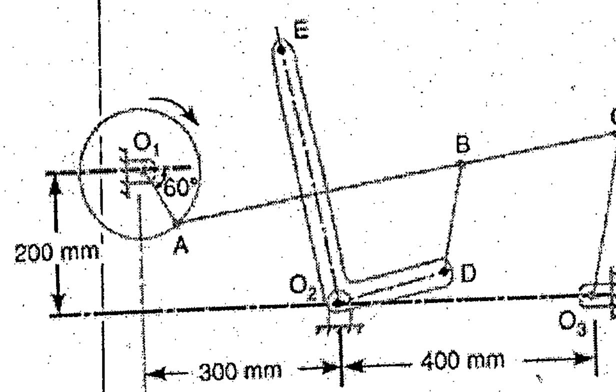


Figure for Q. No. 1(b)

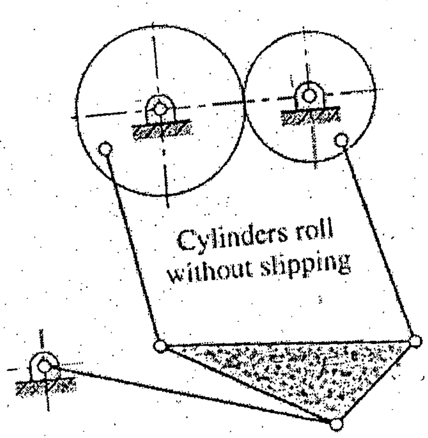


Figure for Q. No. 2(a)

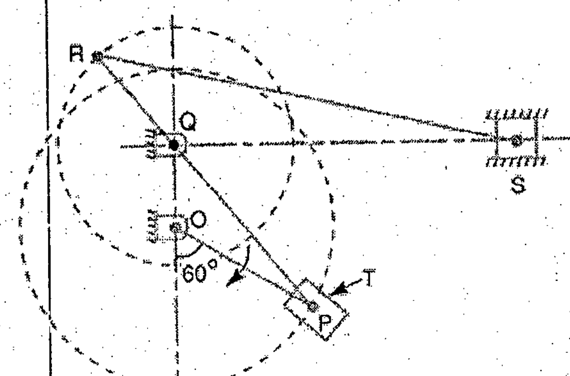


Figure for Q. No. 4(b)

— X —

L-3/T-2/NAME **Date : 16/07/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **MATH 381** (Complex Variables, Harmonic Analysis and Partial Differential Equations)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

SECTION – A

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

1. (a) Determine where the following functions are differentiable **(12)**

(i) $f(z) = x^3 + i(1-y)^3$

(ii) $f(z) = z\,\mathrm{Im}(z)$

Hence discuss the analyticity of these functions.

(b) Write down Cauchy Riemann equations in polar form. Test the differentiability of the function $f(z) = e^{-\theta}\cos(lnr) + ie^{-\theta}\sin(lnr)$, $(r > 0,\ 0 < \theta < 2\pi)$ in the indicated domain and hence show that, $f'(z) = i\dfrac{f(z)}{z}$. **(13⅔)**

(c) Find the principle value of $\left[\dfrac{e}{2}\left(-1-\sqrt{3}i\right)\right]^{3\pi i}$. **(10)**

(d) Show that the transformation, $w = \dfrac{iz+2}{4z+1}$ transform the real axis in the z-plane into circle in the w-plane. Find the centre and radius of the circle. **(11)**

2. (a) Show that $u(x,y) = 3x^2y + 2x^2 - y^3 - 2y^2$ is harmonic. Find an analytic function $f(z)$ in which $u(x,y)$ is the real part. Also express $f(z)$ in terms of z. **(15)**

(b) Solve the equation sinz = 2 by equating the real and imaginary parts in the equation. **(15)**

(c) Evaluate $\int z^2 dz$ along the curve $x = t, y = t^2$ joining the points (1,1) and (2,4). **(16⅔)**

3. (a) Use Cauchy's integral formula to evaluate $\oint_c \dfrac{e^{2z}}{(z+1)^4}dz$, where c is the circle $|z| = 3$. **(15)**

(b) Express $f(z) = \dfrac{z}{(z-1)(2-z)}$ in a Laurent series valid in the region $|z-1| > 1$. **(15⅔)**

(c) Evaluate the integral $\oint_c \dfrac{e^{-iz}}{(z+3)(z-i)^2}dz$ by Cauchy's residue theorem, where $c = \{z : z = 1 + 2e^{i\theta}, 0 \le \theta \le 2\pi\}$. **(16)**

4. Evaluate the following integral using the method of contour integration: **(23+23⅔)**

(i) $\int_0^{2\pi} \dfrac{\sin 2\theta}{5 - 3\cos\theta}d\theta$

(ii) $\int_0^{2\pi} \dfrac{x^2}{(x^2+9)(x^2+4)^2}dx$.

Contd P/2

MATH 381(NAME)

SECTION-B

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

5. (a) Expand $f(x)$ in a half-range Fourier sine and cosine series, where **(26⅔)**

$$f(x)=\begin{cases} x, & 0\le x<1 \\ 2-x, & 1\le x\le 2. \end{cases}$$

Also, sketch the graph of the function.

(b) Find the Fourier integral of the function **(20)**

$$f(x)=\begin{cases} 1+x, & |x|<1 \\ 0, & |x|>1 \end{cases}$$

and hence evaluate $\int_0^\infty \frac{\sin^2\lambda}{\lambda^2}d\lambda$.

6. (a) Find the Fourier cosine integral of the function $f(x)=e^{-x}\cos x$ for $x\ge 0$. **(13)**

(b) Use Finite Fourier Transform to solve the heat equation **(20⅔)**

$$\frac{\partial u}{\partial t}=3\frac{\partial^2 u}{\partial x^2};0<x<\pi,t>0$$

where $u(0,t)=0,u(\pi,t)=0,t\ge 0$ and $u(x,0)=2(1-\cos(\pi x))$ for $0\le x\le\pi$.

(c) Find the steady temperature inside a solid sphere of unit radius if the temperature of its surface is given by $U_0\cos\theta$. **(13)**

7. Solve Laplace's equation $\nabla^2 u=0$ in spherical polar coordinates (r,θ,ϕ) when u is independent of ϕ. **(20)**

(b) Find $L\{J_0(t)\}$ where $J_0(t)$ is the Bessel's function of order zero. Hence find $L\{e^{-3t}J_0(4t)\}$. **(16⅔)**

(c) Prove that $L\{Ci(t)\}=\frac{\ln(s^2+1)}{2s}$. **(10)**

8. (a) Use convolution theorem to find $L^{-1}\left\{\frac{s}{(s^2+4)^3}\right\}$. **(10)**

(b) Use Laplace transform to solve $tX''+X'+4tX=0$ subject to $X(0)=3$ and $X'(0)=0$. **(16)**

(c) Use Laplace transform to solve the following system of differential equations: **(20⅔)**

$$x''(t)+y''(t)=e^{2t}$$
$$2x'(t)+y''(t)=-e^{2t}$$

subject to $x(0)=0,y(0)=0$ and $x'(0)=0,y'(0)=0$.

L-3/T-2/NAME **Date : 09/08/2017**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **NAME 355** (Ship Construction)

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) Briefly mention the main features of general cargo ship. **(6)**

(b) A general cargo ship owner wants to convert his ship from cargo to container ship for his company. What basic structural modification do you suggest for this and why? Justify your answer with necessary sketches of Midship section and compare it with Midship section of the ship mentioned in Q. No. 1(a). **(25)**

(c) Why stabilizers and bow thrust devices are fitted in passenger ships? **(4)**

2. (a) using suitable sketch, distinguish the following: **(24)**

(i) Flat keel and bar keel

(ii) Bracket floor and Plate floor

(iii) Centre girder and side girder

(iv) Swash bulkhead and watertight bulkhead.

(b) Mention the advantages of duct keel. With necessary sketches explain the structural arrangement of duct keel. **(11)**

3. (a) Mention functions of bulkhead. What are the advantages of corrugated bulkhead over plain bulkhead? **(10)**

(b) Explain the function of pillars. How hold pillars are arranged? With neat sketches, describe different types of pillar construction. **(20)**

(c) Mention the name of structural members which contribute to longitudinal strength in a ship. **(5)**

4. (a) With suitable sketches, explain how structural compensation are done in case of unavoidable openings in a ship hall structure. **(12)**

(b) Mention advantages and disadvantages of shot blasting. **(8)**

(c) What is mill scale? Explain natural process of mill scale removal. What are the advantages and disadvantages of process? **(10)**

(d) What are mechanical cutting and water jet cutting of plate? **(5)**

Contd P/2

NAME 355

SECTION-B

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

5. (a) Discuss the advantages and disadvantages of aluminium as shipbuilding material. **(14)**

(b) Categorize the members of International Association of Classification Societies. Discuss the duties of a classification society to maintain assigned class of a vessel. **(14)**

(c) With neat sketch explain the connection between deck longitudinal and web deck beam. **(7)**

6. (a) "The fore part of the ship to severe impact from the sea due to heavy pitching assisted by heaving"- Explain how this part is strengthened. **(20)**

(b) Explain with neat sketches the different types of stern construction of ship. **(15)**

7. (a) Outline the characteristics of shipbuilding steel. Also discuss the effect of high tensile steel in ship structure. **(15)**

(b) Define corrosion cell. What are the corrosion control systems? Discuss in detail. **(10)**

(c) How the ship hull is protected using paint? Explain the role of anti-fouling paint in ship hull maintenance. **(10)**

8. (a) Write short notes on the following: **(21)**

(i) FRP as alternative boat building material

(ii) Bilge keel

(iii) Assembly, sub-assembly and unit in ship construction.

(b) With neat sketch show the erection sequence of general cargo ship. **(14)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **NAME 329** (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. Answer any **THREE**.

Assume suitable values for any missing data. Symbols have their usual meaning.

1. (a) The flow of oil in a journal bearing can be approximated as parallel flow between two large plates with one plate moving and the other stationary. Such flows are known as Couette flow. 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. **(28)**

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

   (ii) Determine the maximum temperature in the oil.

   (iii) Determine the heat flux from the oil to each plate.

   Is the extent of viscous dissipation significant? Suggest how the answers you found could be improved.

   The properties of oil at 20°C are

   $K = 0.145$ W/m.K, $\mu = 0.8374$ kg/m.s.

   (b) Define Prandtl number. Liquid metals have Prandtl number between 0.004 - 0.03, but oils typically have Prandtl number between 50 – 100,000. **(7)**

   Use your definition of Prandtl number to explain this difference.

2. (a) The local atmospheric pressure in Denver, Colorado (elevation 1610 m), is 83 kpa. Air at this pressure and 20°C flows with a velocity of 8 m/s over a 1.5 m × 6 m flat plate whose temperature is 140°C - **(21)**

   (i) Determine the rate of heat transfer from the plate and the total drag force, if the air flows parallel to the 1.5 m side.

   (ii) What would be the effect on the average heat transfer coefficient and rate of heat transfer from the plate, if it is replaced by a 0.75 m × 6 m plate and flow takes place parallel to the 0.75 m side?

   Assume that properties of air at film temperature and 83 kpa pressure are:

   $K = 0.02953$ W/m°C, $P_r = 0.7154$, $\nu = 2.548 \times 10^{-5}$ m²/s.

   (b) For flow of a liquid metal through a circular tube, the velocity and temperature profiles at a particular axial location may be approximated as being uniform and parabolic, respectively. **(14)**

   That is, $u(r) = C_1$ and $T(r) - T_s = C_2\left[1-\left(\frac{r}{r_0}\right)^2\right]$. Where C_1, C_2 are constants, r_0 is the radius of the tube, and T_s is the constant tube surface temperature. Determine the value of Nusselt number Nu_D at this location.

NAME 329

3. (a) For a double pipe parallel flow heat exchanger, derive the expression of the log-mean temperature difference. State any assumption you made in the derivation. **(20)**

(b) A counter flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160 °C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2 °C, determine the length of the heat exchanger required to achieve the designed heating. Assume the specific heat water and geothermal fluid to be 4.18 and 4.31 KJ/kg °C respectively. **(15)**

4. (a) Determine the view factor from any one side to any other side of the infinitely long triangular duct whose cross-section is given in figure for question no. 4(a). **(17)**

(b) Draw the radiation network for two parallel infinite planes separated by one radiation shield. Hence derive the ratio of radiation heat transfer with N Shields present and without any shield present between two infinite parallel planes with all the surfaces having equal emissivity. **(18)**

A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 k and have emissivities ϵ_1= 0.2, ϵ_2= 0.7, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield.

SECTION-B

There are **FOUR** questions in this section. Answer any **THREE** questions.
Assume reasonable value for any missing data.

5. (a) Deduce the following equation for one dimensional heat flow through a hollow cylinder. **(20)**

$$q = \frac{2\lambda kL(T_i - T_o)}{In(r_0/r_i)}$$

Where symbols have their usual meaning. Hence, determine the thermal resistance and construct the electric analog of this resistance.

(b) An exterior wall of a house may be approximated by a 4-in layer of common brick [K = 0.7 W/m °C] followed by a 1.5-in layer of gypsum plaster [K = 0.48 W/m °C]. What thickness of loosely packed rock-wool insulation [K = 0.65 W/m °C] should be added to reduce the heat loss (or gain) through the wall by 80 percent? **(15)**

NAME 329

6. (a) A 3 mm diameter and 5-m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is K = 0.15 W/m °C. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at T_α = 30 °C with a heat transfer co-efficient of h = 12 W/m^2 °C, determine the temperature of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic cover will increase or decrease this interface temperature. **(15)**

   (b) Derive a relation for the critical radius of insulation for a sphere. Hence explain the effect of insulation on heat transfer plate. **(20)**

7. (a) A long 20-cm diameter cylindrical shaft made of stainless steel 304 comes out of an oven at a uniform temperature of 600°C. The shaft is then allowed to cool slowly in an environment chamber at 200 °C with an average heat transfer co-efficient of h = 80 W/m^2 °C. Determine the temperature at the center of the shaft 45 min after the start of cooling process. Also, determine the heat transfer per unit length of the shaft during this time period. **(20)**

   [The properties of stainless steel 304 at room temperature are K = 14.9 W/m °C, ρ = 7900 kg/m^3, C_p = 477 J/kg. °C, and $\alpha = 3.95 \times 10^{-6}$ m^2/s.]

   (b) The temperature of a gas stream is to be measured by a thermocouple. The time it takes to register 99 percent of the initial ΔT is to be determined. Consider the following properties of the junction: **(15)**

   d = 0.0012 m, K = 35 W/m °C, ρ = 8500 kg/m^3 and C_p = 320 J/kg °C, h = 90 W/m^2 °C.

8. (a) Show that, for an infinitely long fin, the heat transferred by the fin from its base is equal to the convection heat transfer from the fin surface to the surrounding fluid. **(15)**

   (b) A square plate [0.8 m × 0.8 m] is kept in a room at 28 °C. One side of the plate is insulated while other side is maintained at 80 °C. Determine the rate of the heat transfer through the plate by natural convection if the plate is (i) vertical, (ii) horizontal with hot surface facing up, (ii) horizontal with hot surface facing down. Given that, properties of air at film temperature are **(20)**

$$k = 0.02808\ \text{W/m}^0\text{C} \quad P_r = 0.7202$$
$$\nu = 1.896 \times 10^{-5}\ \text{m}^2/\text{s} \quad \beta = \frac{I}{T_f}$$

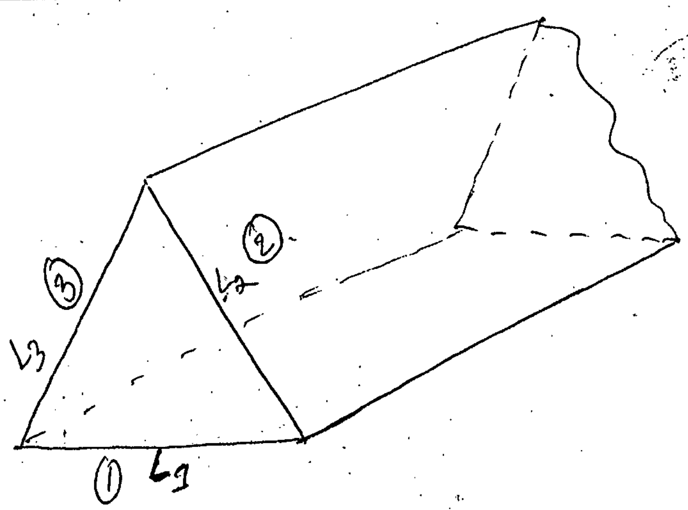
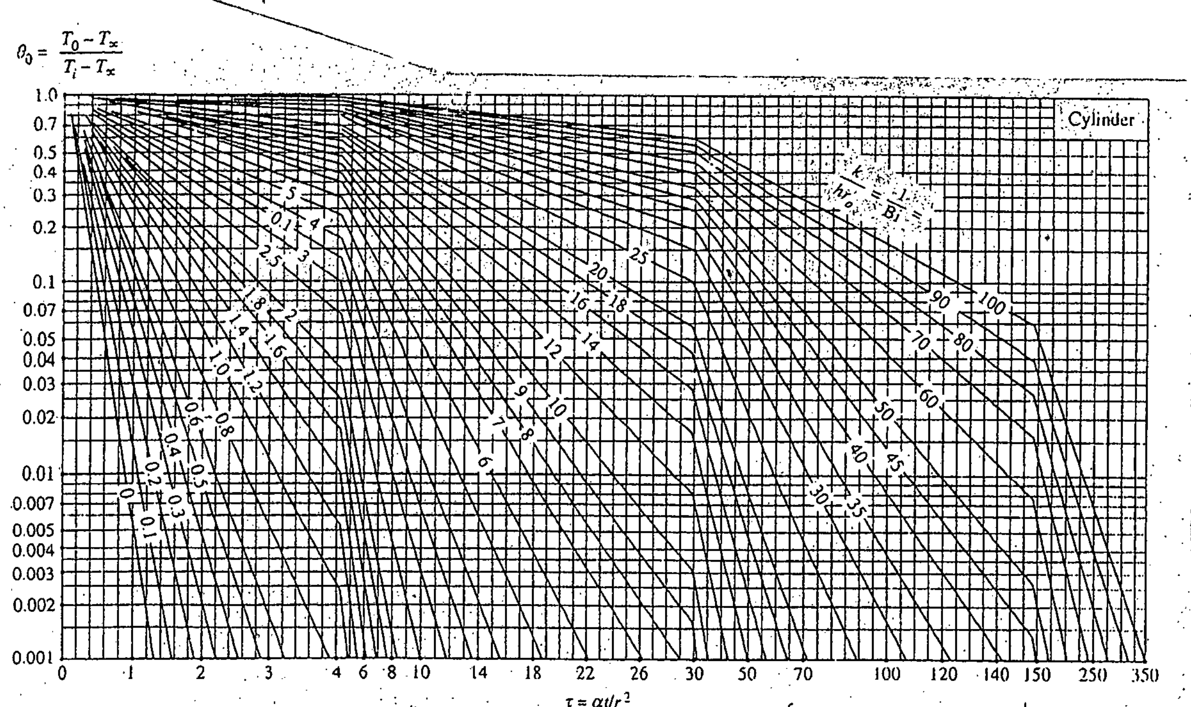
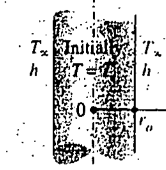
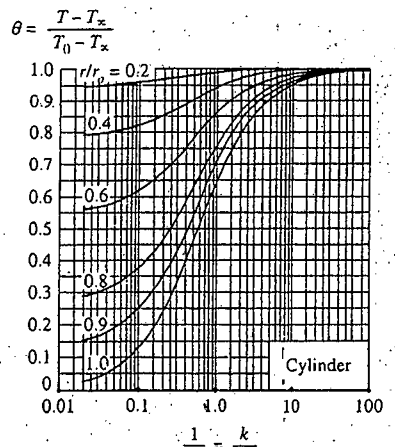


figure for question number 4(a)

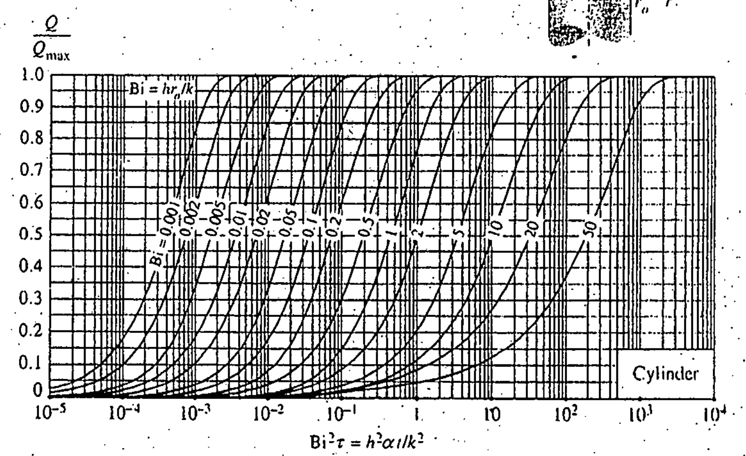


(*a*) Centerline temperature (from M. P. Heisler, "Temperature Charts for Induction and Constant Temperature Heating," *Trans. ASME 69*, 1947, pp. 227–36. Reprinted by permission of ASME International.)





(*b*) Temperature distribution (from M. P. Heisler, "Temperature Charts for Induction and Constant Temperature Heating," *Trans. ASME 69*, 1947, pp. 227–36. Reprinted by permission of ASME International.)



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

[redacted] Transient temperature and heat transfer charts for a long cylinder 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.

7(a)

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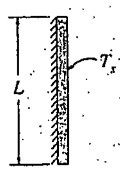
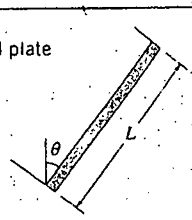
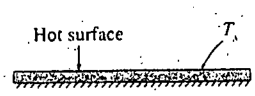
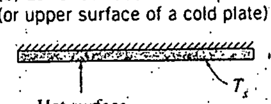
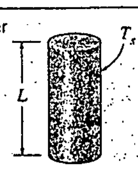
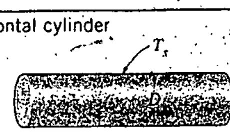
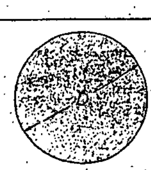
NAME 329

Empirical correlations for the average Nusselt number for natural convection over surfaces

Geometry	Characteristic length L_c	Range of Ra	Nu	
Vertical plate 	L	10^4–10^9 10^{10}–10^{13} Entire range	$Nu = 0.59Ra_L^{1/4}$ $Nu = 0.1Ra_L^{1/3}$ $Nu = \left\{0.825 + \frac{0.387Ra_L^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}}\right\}^2$ (complex but more accurate)	(9–19) (9–20) (9–21)
Inclined plate 	L		Use vertical plate equations for the upper surface of a cold plate and the lower surface of a hot plate Replace g by $g \cos\theta$ for $Ra < 10^9$	
Horizontal plate (Surface area A and perimeter p) (a) Upper surface of a hot plate (or lower surface of a cold plate)  (b) Lower surface of a hot plate (or upper surface of a cold plate) 	A_s/p	10^4–10^7 10^7–10^{11} 10^5–10^{11}	$Nu = 0.54Ra_L^{1/4}$ $Nu = 0.15Ra_L^{1/3}$ $Nu = 0.27Ra_L^{1/4}$	(9–22) (9–23) (9–24)
Vertical cylinder 	L		A vertical cylinder can be treated as a vertical plate when $D \geq \frac{35L}{Gr_L^{1/4}}$	
Horizontal cylinder 	D	$Ra_D \leq 10^{12}$	$Nu = \left\{0.6 + \frac{0.387Ra_D^{1/6}}{[1 + (0.559/Pr)^{9/16}]^{8/27}}\right\}^2$	(9–25)
Sphere 	D	$Ra_D \leq 10^{11}$ $(Pr \geq 0.7)$	$Nu = 2 + \frac{0.589Ra_D^{1/4}}{[1 + (0.469/Pr)^{9/16}]^{4/9}}$	(9–26)

8(b)

—x—