L-2/T-2/CHE **Date : 01/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **CHE 205** (Fluid Mechanics)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) By an appropriate dimensional analysis, determine the expression for the shear stress at the wall when an incompressible fluid flows in a pipe under pressure. The significant parameters are velocity of flow V, diameter of Pipe D, and viscosity $\mu$ and density $\rho$ of the fluid. **(17)**

   (b) Models are to be built for a number of prototypes. For dynamic similarity, indicate which single dimensionless ratio will govern for the followings: **(2×4=8)**

   (i) Oil flowing through a full pipeline, (ii) a water jet, (iii) a deep submersible vehicle, and (iv) a missile (supersonic).

   (c) The flow over a spillway is 150 $m^3/s$. For dynamic similarity, what should be the model scale if the model flow rate is to be 1.35 $m^3/s$? The force on certain area of the model is measured to be 5 N. What would be the force on the corresponding area of the prototype? **(5+5=10)**

2. (a) Explain how a pump of suitable type and optimum size and rating is to be selected for a specific application. **(13)**

   (b) Answer the followings in the context of centrifugal pumps: **(4×3=12)**

   (i) How can the cavitation be prevented robustly?

   (ii) When is priming not required?

   (iii) Demonstrate graphically how the energy losses occurring within a pump varies typically with discharge.

   (c) A centrifugal pump with a 30 cm-diameter impeller is rated at 30 L/s against a head of 24 m when rotating at 1750 rpm. What would be the rating of a pump of identical geometric shape with a 15 cm impeller? Assume pump efficiencies are identical and rotative speed is doubled for 15 cm-diameter impeller. **(10)**

3. (a) Discuss the application and operating principle of the following fluid measurement devices: **(4×4=16)**

   (i) Saybolt viscometer

   (ii) Hot-Film Anemometer

   (iii) Venturi Meter

   (iv) Interferometer

Contd ..... P/2

## CHE 205

**Contd ... Q. No. 3**

(b) According to increased complexity, present the approaches used for modeling multiphase flows indicating their key features. **(10)**

(c) State the specialty of CFD and elaborate the fundamental steps of CFD process. **(4+5=9)**

4. (a) Write down the principle(s) or general equation(s) required for the derivation of 'equations of change'. Also, state the conditions at which the equation of motion turns to Navier-Stokes equation. **(4+4=8)**

(b) With the help of required equation(s) and figure(s), explain the effect of area variation on one-dimensional compressible flow. **(11)**

(c) Demonstrate graphically how pressure, velocity, and temperature vary with distance along pipe in the subsonic flow of a compressible fluid in a pipe of constant diameter. **(6)**

(d) With the help of a sketch, show the different flow regions observed in a vertical gas-liquid flow system when the gas flow rate is increased. Also show the regions in a gas-flux vs. liquid-flux diagram. **(5+5=10)**

### SECTION – B

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

5. (a) In Fig. for Q. 5(a), assume the following: atmospheric pressure equal 900 mbar abs; vapor pressure of the alcohol equal to 130 mbar abs; = 3.50 m and y = 1.80 m. Compute the reading on the pressure gauge and on the manometer. **(20)**

(b) Fig. for Q. 5(b) shows a gate, to fit wide perpendicular to the sketch. It is pivoted at hinge H. The gate weighs 500 lb. Its center of gravity is 1.2 feet to the right of and 0.9 feet above H. For what values of water depth x above H will the gate remain closed? Neglect friction at the pivot and neglect thickness of the gate. **(15)**

6. (a) Water flows in a wide open channel as shown in Fig. for Q. 6(a). Two pitot tubes are connected to a differential manometer containing a liquid (s.= 0.82), Find $u_A$ and $u_B$. **(15)**

(b) In a fire fighting system, a pipeline with a pump leads to a nozzle as shown in Fig. for Q. 6(b). Find the flowrate when the pump develops a head of 80 feet. Assume that the head loss in the 6-in-diameter pipe may be expressed by $h_L = 5V_6^2/2g$, while the headloss in the 4-in-diameter pipe is $h_L = 12V_4^2/2g$. Sketch the energy line and hydraulic grade line, and find the pressure head at the suction side of the pump. **(20)**

Contd ..... P/3

## CHE 205

7. (a) The headloss in 200 ft of 6 in-dia pipe is known to be 25 ft-lb/lb when oil (s = 0.90) of viscosity 0.00088 lb-sec/ft$^2$flows at 2 cfs. Determine the centerline velocity, the shear stress at the wall of the pipe, and the velocity at 2 in from the centerline. **(16)**

   (b) Draw clearly the Moody diagram and discuss its various region. **(19)**

8. (a) A 12-in-diameter pipe (f = 0.02) carries fluid between two tanks at 8 fps. The entrance and exit conditions to an from the pipe are square-edged and flush with the wall of the tank. Find the ratio of the minor losses divided by the pipe friction loss if the length of the pipe is (i) 4 ft, (ii) 80 ft, (iii) 1600 ft. **(17)**

   (b) Two pipes with a diameter ratio of 1 : 2 are connected in series. With a velocity of 7.5 m/s in the smaller pipe, find the loss of head due to (i) sudden contraction, (ii) sudden enlargement, (iii) expansion in a conical diffuser with a total angle of 30° and of 10°. **(18)**

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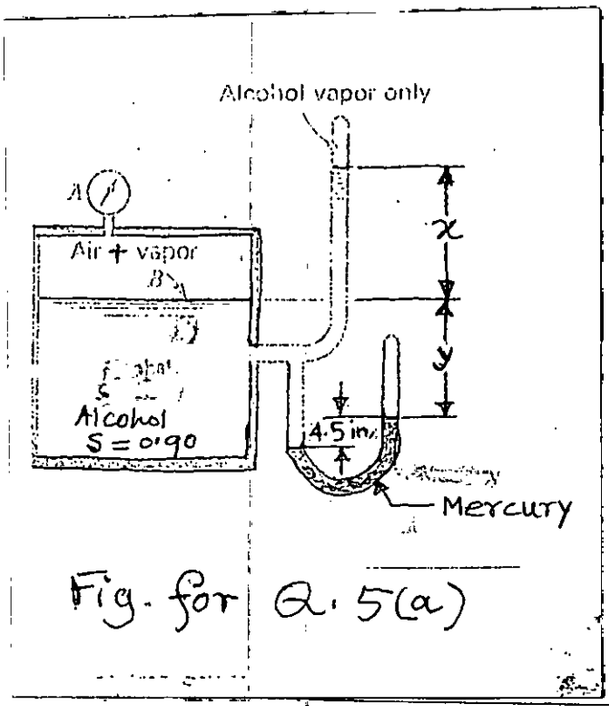


Fig. for Q. 5(a)

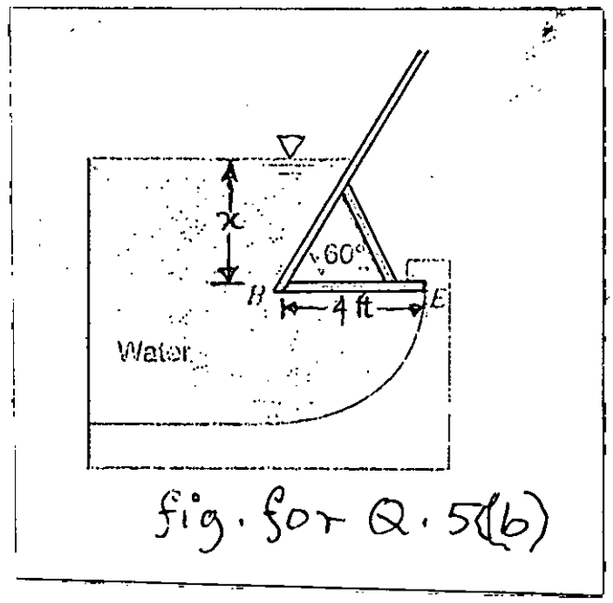


fig. for Q. 5(b)

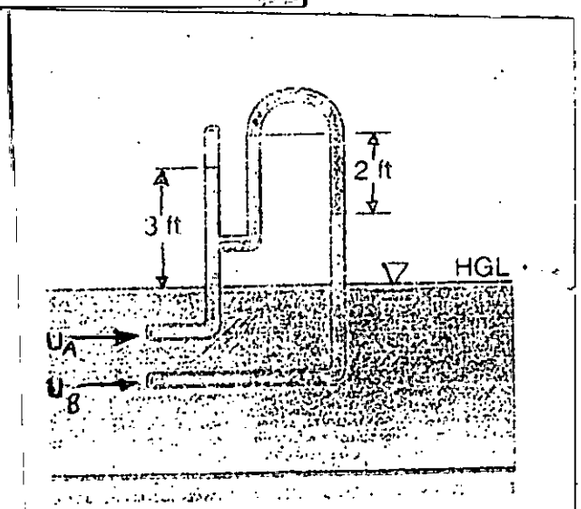


fig. for Q(6(a)

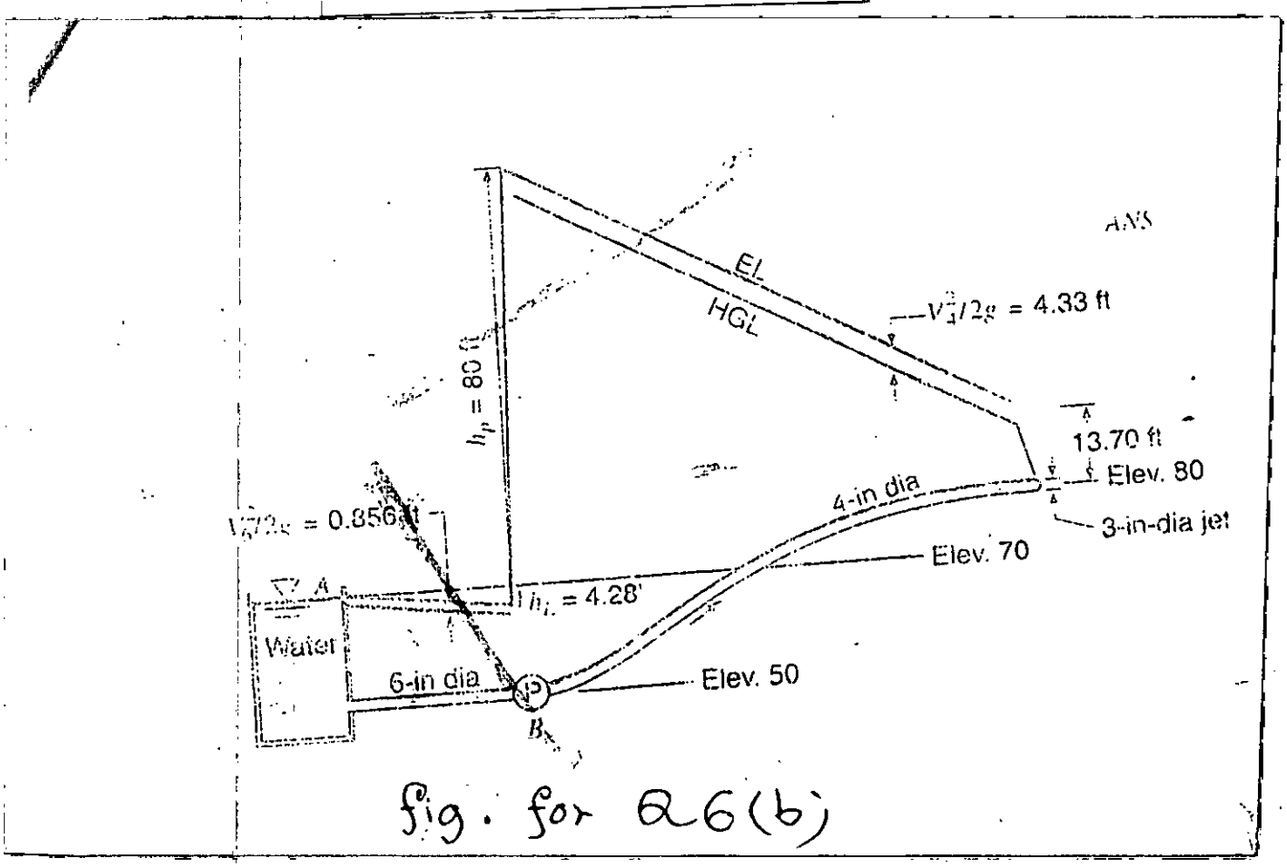


fig. for Q6(b)

L-2/T-2/CHE **Date: 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHEM 221** (Organic Chemistry)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

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## SECTION – A

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

1. (a) Give one commercial method of synthesis for each of the following: **(9)**

   (i) Pyrrole (ii) Furan (iii) Thiophene

   (b) Prove that pyrrole is not only a weak base but also a weak acid. **(6)**

   (c) Show the reactivity order of the five-membered heterocycles during electrophilic substitution reaction. **(5)**

   (d) Write with reactions how would you bring out the following conversions:- **(3×5=15)**

   (i) 2,3,4,5 - Tetrahydropyrrole from pyrrole

   (ii) 2, 5 - Dihydropyrrole from pyrrole

   (iii) 2 - Lithium furan from furan

   (iv) n-Butane from thiophene

   (v) Thiophene - 2- carboxylic acid from thiophene

2. (a) Give a view of the molecular orbital picture of pyridine. How will you prove the aromaticity of pyridine? **(10)**

   (b) Deduce a tentative structure for pyridine by degradative methods and confirm it by a synthesis. **(10)**

   (c) Explain the mechanism of nucleophilic substitution reaction of pyridine with examples. **(10)**

   (d) Mention some medicinal uses of pyridine. **(5)**

3. (a) Describe with mechanism why quinoline gives electrophilic substitution reaction at C-5 and C-8 positions. **(10)**

   (b) What happens when quinoline is subjected to oxidation by (i) peracetic acid and (ii) alkaline potassium permanganate? **(5)**

Contd ..... P/2

**CHEM 221/CHE**

**Contd... Q. No. 3**

(c) Explain how the bromination reactions differ between benzene and an alkene. **(10)**

(d) Discuss the significance of carbocation rearrangements in Friedel-Crafts alkylation reactions of benzene with examples. **(10)**

4. (a) What are the necessary and sufficient conditions for a substance to be a perfect dye? Show the preparation of an azo dye involving the various steps. **(10)**

(b) How the functional natural of nitrogen can be identified in the structure of alkaloids? **(10)**

(c) Prove that nicotine contains a pyridine nucleus with a side chain of pyrrole derivative. **(10)**

(d) Mention some physiological activities of alkaloids. **(5)**

**SECTION – B**

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

5. (a) A compound with a molecular formula $C_6H_{14}$ has two 3° hydrogen atoms. Give the structure and IUPAC name of the compound. How will you prepare the compound by 'Wurtz reaction'? Discuss with mechanism. **(15)**

(b) Which one of the following pairs has higher boiling point and why? **(10)**

(i) cis– 1, 2 – dibromoethene and trans -1, 2-dibromoethene

(ii) n-butane and 2-methly propane

(c) Draw the Newman projections for both the least and the most stable conformations of 1, 2 - dibromoethane. Explain your answer.

How will you synthesize acetylene from 1, 2 - dibromoethane? **(10)**

6. (a) Explain the followings: **(5×3=15)**

(i) Both vinylic and aryl halides are unreactive towards $S_N1$ and $S_N2$ reactions.

(ii) The order of reactivity of $I^- > Br^- > Cl^- > F^-$ towards $CH_3Br$ in water is reversed in DMF solution.

(iii) Neopentyl halides cannot be made to undergo substitution reaction.

(b) $CH_2 = CHCH_2CH_3$ is formed as a major product from $CH_3CH(Br)\ CH_2CH_3$ when $(CH_3)_3\ CO^-K^+$ is used as base for dehydrobromination. Explain. **(10)**

Contd ..... P/3

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**Contd... Q. No. 6**

(c) What are the disadvantages in the preparation of alkenes by the following reactions? **(10)**

(i) R-X + Base and (ii) R-OH + Acid.

Explain with examples.

7. (a) Define stereoselectivity and regiosetectivity. Demonstrate by an example that 'hydroboration-oxidation' method of preparation of an alcohol from an alkene is regioselective. **(15)**

(b) Prepare $(CH_3)_3$ C-O-$CH_3$ by Williamson's method. Use either the reaction of **(10)**

(i) methyl bromide and K-t-butoxide

or

ii) t-butyl bromide and K-methoxide. Indicate a route of your choice with reasoning.

(c) n-propyl alcohol reacts with $H_2SO_4$ at 170°C to form compound (A), which reacts with HBr and give compound (B). Compound (B) again reacts with aq. KOH to form compound (C). What are the structural formulas of (A), (B) and (C)? Give equations for all the reactions. **(10)**

8. (a) Bromination of olefins is always carried out in $CCl_4$ but not in $CH_3OH$. Explain. **(15)**

State the possible products with mechanism when ethylene is treated with bromine in methanolic solution.

(b) What alkenes would you expect from the following compounds? Give the experimental conditions in each case. **(10)**

(i) $(CH_3)_3CCl$

(ii) $CH_3CH(OH)C(CH_3)_3$

(c) Write a note on 'Oxymercuration – demercuration' reaction. **(10)**

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L-2/T-2/CHE **Date: 20/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **HUM 103** (Economics)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

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## SECTION – A

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

1. (a) Define supply function. **(5)**

   (b) What are the factors that influence the shifting of the supply curve? **(10)**

   (c) From the following demand function, make a hypothetical demand schedule and plot the curve. **(10)**

   $$Q = 90 - 20P + P^2$$

   (d) What are the exceptions to the law of demand? Explain. **(10)**

2. (a) Define Income elasticity of demand and price elasticity of demand. **(10)**

   (b) How would you measure price elasticity of demand at any point on a straight line demand curve? Explain graphically **(15)**

   (c) From the following table calculate elasticity of demand if you move from point A to C and explain what you understand from the result. **(10)**

| POINT | Px | Qy |
|---|---|---|
| A | 500 | 120 |
| B | 600 | 150 |
| C | 700 | 180 |

3. (a) How is price determined in an open economy? What will happen to the equilibrium price and quantity because of change in demand and supply? **(15)**

   (b) From the following demand and supply functions, calculate equilibrium price and quantity and show the result in a graph. **(20)**

   $$P = 0.50\,Q + 250$$

   $$P = -0.40Q + 340$$

   (i) What will happen to the equilibrium price and quantity if government imposes a unit tax of TK 15 per unit? **(20)**

Contd ..... P/2

**HUM 103/CHE**

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

(ii) What will happen if government gives a subsidy of TK 20 per unit?

(iii) Describe the change in equilibrium. Show the equilibrium coordinates on the same graph.

4. (a) Write short notes on fiscal policy and monetary policy with reference to Bangladesh. **(15)**

(b) Explain and show graphically the effects of "cost push inflation" and demand pull inflation" on any economy considering other things remaining constant. **(20)**

**SECTION – B**

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

5. A firm producing two goods "X" and "Y" has the profit function

$Z = 6400X - 200X^2 + 400XY - 400Y^2 + 3200Y - 1300$

(a) What are the profit-maximizing level of output for each of the two goods? **(20)**

(b) Test whether profits are maximized. What is the maximized amount of profit? **(15)**

6. (a) Explain and show graphically super normal profit, abnormal loss and zero profit/normal profit of a firm under perfect competition. **(20)**

(b) The Market price in a perfectly competitive market is Tk 102. A perfectly competitive firm has a marginal cost given by MC = 2 + 2Q, where Q stands for quantity produced. Find the profit maximizing output and revenue. **(15)**

7. (a) If the consumption function is given by the equation $C = 600 + 0.5Y$, the production function is $Y = 100K^{0.5}L^{0.5}$, where C = consumption, Y = Total output, $K$ - Capital = 100 and $L$ = Land = 100, then what will be the amount of C? **(20)**

(b) Define GDP deflator. How can you calculate inflation rate using GDP deflator? Consider a hypothetical economy. Using the information given in the following table, calculate the inflation rates from 2017 to 2018, from 2018 to 2019, and from 2019 to 2020. **(15)**

| | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Nominal GDP | 30,099 | 35,099 | 37,099 | 40,099 |
| Real GDP | 27,099 | 30,799 | 32,099 | 35,099 |

Contd ..... P/3

8. (a) Assume Consumption ($C$) is given by the equation $C = 600 + 0.6(Y - T)$. Taxes ($T$) are equal to 600. Government spending is equal to 1,000. Investment is given by the equation $I = 2{,}160 - 100r$, where $r$ = the real interest rate = 13 percent. In this case, what is the equilibrium level of total output ($Y$)? How does the equilibrium income change if government designs and executes expansionary fiscal policy? Show graphically and mathematically. **(20)**

(b) Assume that Gross Domestic Product (GDP)/Total output ($Y$) is 6,000. Consumption ($C$) is given by the equation C = 625 + 0.6(Y – T) where T is the tax. Investment ($I$) is given by the equation $I = 2{,}000 - 100r$, where r is the real rate of interest, in percent. Taxes ($T$) are 525, and government spending (G) is also 525. What are the equilibrium values of C, I, and r? **(15)**

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L-2/T-2/CHE **Date: 26/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 223** (Numerical Analysis and Statistics)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

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## SECTION – A

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

1. (a) Derive Newton's divided difference interpolation formula. Using the formula find a polynomial of degree four which approximates the following data: **(17)**

| $x$ | −1 | 0 | 3 | 6 | 7 |
|---|---|---|---|---|---|
| $y$ | 3 | −6 | 39 | 822 | 1611 |

(b) Find the value of '$x$' for which $f(x) = 85$ from the following table using Lagrange's inverse interpolation formula: **(18)**

| $x$ | 2 | 5 | 8 | 14 |
|---|---|---|---|---|
| $f(x)$ | 94.8 | 87.9 | 81.3 | 68.7 |

2. (a) Approximate the integral $\int_{1.0}^{2.8} x^2 \ln x \, dx$ using (i) Open Newton - Cotes quadrature formula ($n = 3$) and (ii) Simpson's $\frac{3}{8}$ rule. Determine the better approximation by comparing the results obtained with the exact value of the integral. **(18)**

(b) Approximate the integral $\int_0^{\pi/2} \sqrt{1+\cos^2 x}\, dx$ using Gauss Legendre quadrature formula for $n = 5$. [Nodes and corresponding weights are given in the attached Table-1] **(17)**

3. (a) Construct the least squares approximation of the form $y = a_0 e^{a_1 x}$ and compute the error for the data given in the following table: **(17)**

| $x$ | 0.2 | 0.3 | 0.6 | 0.9 | 1.1 | 1.3 | 1.4 |
|---|---|---|---|---|---|---|---|
| $y$ | 0.05045 | 0.09843 | 0.33227 | 0.72660 | 1.0972 | 1.5697 | 1.8487 |

(b) Using Regula - Falsi method find a solution of the equation **(18)**

$$(x-2)^2 - \ln x = 0 \begin{cases} \text{for} & 1 \le x \le 2 \\ \text{and} & e \le x \le 4 \end{cases}$$

Correct to four decimal places.

Contd ..... P/2

4. (a) Describe Newton-Raphson method for solving a root-finding problem. Using Newton-Raphson method, find a real root of the equation $x\sin x + \cos x = 0$ correct to four decimal places, assuming that the root is near to $\pi$. **(17)**

(b) Use Runge-Kutta method of fourth order to solve the following differential equation at $x = 0.2$ and $x = 0.4$, **(18)**

$$\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2} \quad ; \quad y(1) = 0.$$

## SECTION – B

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

5. (a) Evaluate the first order derivative $f'(x)$ at each $x$ from the following table: **(18)**

| $x$ | 8.1 | 8.3 | 8.5 | 8.7 |
|---|---|---|---|---|
| $f(x)$ | 16.94410 | 17.56492 | 18.19056 | 18.82091 |

(b) Apply Newton's method to find a solution near to $x = 0.5$, $y = 0.5$ correct to three decimal place of the non-linear system: **(17)**

$$x^2 - 2x - y + 0.5 = 0$$
$$x^2 + y^2 - 2 = 0$$

6. (a) A small business Website contains 100 pages and 60%, 30%, and 10% of the pages contain low, moderate, and high graphic content, respectively. A sample of four pages is selected without replacement, and $X$ and $Y$ denote the number of pages with moderate and high graphics output in the sample. Determine the following: **(15)**

I. Joint probability distribution of random variables $X$ and $Y$

II. Marginal distribution of $X$ and $Y$.

III. Variance of $X$ and $Y$.

(b) Determine the value profit of "$c$" that makes the function $f(x, y) = cxy$ a joint probability density function over the region $0 < x < 3$ and $0 < y < 3$. Also calculate the followings: **(20)**

I. $P(X < 2, Y < 3)$

II. Marginal distribution of $X$ and $Y$.

III. Expected value of $XY$.

7. (a) Define Binomial distribution. The random variable X has a Binomial distribution with $n = 10$ and $p = 0.5$. **(12)**

(i) Sketch the probability distribution function of X.

Contd ..... P/3

## MATH 223/CHE

**Contd... Q. No. 7(a)**

(ii) Sketch the cumulative distribution function of X.

(iii) What value of X is most likely?

(iv) What value(s) of X is (are) least likely?

(b) The compressive strength of samples of cement can be modeled by a normal distribution with a mean of 6000 kg/cm$^2$ and standard deviation of 100 kg/cm$^2$. **(12)**

(i) What is the probability that a sample's strength is between 5800 and 5900 kg/cm$^2$?

(ii) What strength is exceeded by 95% of the samples? (Table-2 attached)

(c) Consider an experiment that consists of counting the number of $\alpha$ particles given off in a one second interval by one gram of radioactive material. If we know from the past experience that on an average 3.2 such $\alpha$ particles are given off, what is a good approximation to the probability that no more than two such particles will appear? **(11)**

8. (a) A bulb manufacturing company claims that the average longevity of their bulb is 4 years with a standard deviation of 0.16 years. A random sample of 40 bulbs gave a mean longevity of 3.45 years. Does the sample mean justify the claim of the manufacturer? Use 5% level of significance. **(15)**

(b) Data for 8 individuals were recorded in the following table. **(20)**

i. Find the correlation coefficient between $X$ and $Y$.

ii. Determine the regression coefficient of $Y$ on $X$.

| X | 65 | 66 | 67 | 67 | 68 | 69 | 70 | 72 |
|---|---|---|---|---|---|---|---|---|
| Y | 67 | 68 | 65 | 68 | 72 | 72 | 69 | 71 |

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# Table-01

| $n$ | Roots $r_{n,i}$ | Coefficients $c_{n,i}$ |
|---|---|---|
| 2 | 0.5773502692 | 1.0000000000 |
| | −0.5773502692 | 1.0000000000 |
| 3 | 0.7745966692 | 0.5555555556 |
| | 0.0000000000 | 0.8888888889 |
| | −0.7745966692 | 0.5555555556 |
| 4 | 0.8611363116 | 0.3478548451 |
| | 0.3399810436 | 0.6521451549 |
| | −0.3399810436 | 0.6521451549 |
| | −0.8611363116 | 0.3478548451 |
| 5 | 0.9061798459 | 0.2369268850 |
| | 0.5384693101 | 0.4786286705 |
| | 0.0000000000 | 0.5688888889 |
| | −0.5384693101 | 0.4786286705 |
| | −0.9061798459 | 0.2369268850 |

For Question 2(b)

# Table-02

Table (continued) Areas under the Normal Curve

| $z$ | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.5000 | 0.5040 | 0.5080 | 0.5120 | 0.5160 | 0.5199 | 0.5239 | 0.5279 | 0.5319 | 0.5359 |
| 0.1 | 0.5398 | 0.5438 | 0.5478 | 0.5517 | 0.5557 | 0.5596 | 0.5636 | 0.5675 | 0.5714 | 0.5753 |
| 0.2 | 0.5793 | 0.5832 | 0.5871 | 0.5910 | 0.5948 | 0.5987 | 0.6026 | 0.6064 | 0.6103 | 0.6141 |
| 0.3 | 0.6179 | 0.6217 | 0.6255 | 0.6293 | 0.6331 | 0.6368 | 0.6406 | 0.6443 | 0.6480 | 0.6517 |
| 0.4 | 0.6554 | 0.6591 | 0.6628 | 0.6664 | 0.6700 | 0.6736 | 0.6772 | 0.6808 | 0.6844 | 0.6879 |
| 0.5 | 0.6915 | 0.6950 | 0.6985 | 0.7019 | 0.7054 | 0.7088 | 0.7123 | 0.7157 | 0.7190 | 0.7224 |
| 0.6 | 0.7257 | 0.7291 | 0.7324 | 0.7357 | 0.7389 | 0.7422 | 0.7454 | 0.7486 | 0.7517 | 0.7549 |
| 0.7 | 0.7580 | 0.7611 | 0.7642 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7794 | 0.7823 | 0.7852 |
| 0.8 | 0.7881 | 0.7910 | 0.7939 | 0.7967 | 0.7995 | 0.8023 | 0.8051 | 0.8078 | 0.8106 | 0.8133 |
| 0.9 | 0.8159 | 0.8186 | 0.8212 | 0.8238 | 0.8264 | 0.8289 | 0.8315 | 0.8340 | 0.8365 | 0.8389 |
| 1.0 | 0.8413 | 0.8438 | 0.8461 | 0.8485 | 0.8508 | 0.8531 | 0.8554 | 0.8577 | 0.8599 | 0.8621 |
| 1.1 | 0.8643 | 0.8665 | 0.8686 | 0.8708 | 0.8729 | 0.8749 | 0.8770 | 0.8790 | 0.8810 | 0.8830 |
| 1.2 | 0.8849 | 0.8869 | 0.8888 | 0.8907 | 0.8925 | 0.8944 | 0.8962 | 0.8980 | 0.8997 | 0.9015 |
| 1.3 | 0.9032 | 0.9049 | 0.9066 | 0.9082 | 0.9099 | 0.9115 | 0.9131 | 0.9147 | 0.9162 | 0.9177 |
| 1.4 | 0.9192 | 0.9207 | 0.9222 | 0.9236 | 0.9251 | 0.9265 | 0.9279 | 0.9292 | 0.9306 | 0.9319 |
| 1.5 | 0.9332 | 0.9345 | 0.9357 | 0.9370 | 0.9382 | 0.9394 | 0.9406 | 0.9418 | 0.9429 | 0.9441 |
| 1.6 | 0.9452 | 0.9463 | 0.9474 | 0.9484 | 0.9495 | 0.9505 | 0.9515 | 0.9525 | 0.9535 | 0.9545 |
| 1.7 | 0.9554 | 0.9564 | 0.9573 | 0.9582 | 0.9591 | 0.9599 | 0.9608 | 0.9616 | 0.9625 | 0.9633 |
| 1.8 | 0.9641 | 0.9649 | 0.9656 | 0.9664 | 0.9671 | 0.9678 | 0.9686 | 0.9693 | 0.9699 | 0.9706 |
| 1.9 | 0.9713 | 0.9719 | 0.9726 | 0.9732 | 0.9738 | 0.9744 | 0.9750 | 0.9756 | 0.9761 | 0.9767 |
| 2.0 | 0.9772 | 0.9778 | 0.9783 | 0.9788 | 0.9793 | 0.9798 | 0.9803 | 0.9808 | 0.9812 | 0.9817 |
| 2.1 | 0.9821 | 0.9826 | 0.9830 | 0.9834 | 0.9838 | 0.9842 | 0.9846 | 0.9850 | 0.9854 | 0.9857 |
| 2.2 | 0.9861 | 0.9864 | 0.9868 | 0.9871 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.9890 |
| 2.3 | 0.9893 | 0.9896 | 0.9898 | 0.9901 | 0.9904 | 0.9906 | 0.9909 | 0.9911 | 0.9913 | 0.9916 |
| 2.4 | 0.9918 | 0.9920 | 0.9922 | 0.9925 | 0.9927 | 0.9929 | 0.9931 | 0.9932 | 0.9934 | 0.9936 |
| 2.5 | 0.9938 | 0.9940 | 0.9941 | 0.9943 | 0.9945 | 0.9946 | 0.9948 | 0.9949 | 0.9951 | 0.9952 |
| 2.6 | 0.9953 | 0.9955 | 0.9956 | 0.9957 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 |
| 2.7 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 |
| 2.8 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9977 | 0.9978 | 0.9979 | 0.9979 | 0.9980 | 0.9981 |
| 2.9 | 0.9981 | 0.9982 | 0.9982 | 0.9983 | 0.9984 | 0.9984 | 0.9985 | 0.9985 | 0.9986 | 0.9986 |
| 3.0 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 |
| 3.1 | 0.9990 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9993 |
| 3.2 | 0.9993 | 0.9993 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9995 | 0.9995 | 0.9995 |
| 3.3 | 0.9995 | 0.9995 | 0.9995 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9997 |
| 3.4 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 |

For question NO 7(b)

L-2/T-2/CHE **Date : 25/09/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 243** (Mechanics of Solids)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Notations have their usual meanings.

1. (a) Write the shear force and bending moment equations for the beam shown in Fig. 1(a). Also draw the shear force and bending moment diagrams for the beam. **(17)**

   (b) Determine the ratio of maximum shear stress to maximum bending stress in the flange of WF section of the beam shown in Fig. 1(a). **(18)**

2. (a) A bending moment acting on the curved beam with a rectangular cross section as in Fig. 2(a) is M = 8 kN.m. Calculate the bending stress at point B. **(17)**

   (b) A reinforced concrete beam shown in Fig. 2(b) is subjected to a positive bending moment of 175 kN.m, Knowing that the modulus of elasticity is 25 GPa for the concrete and 200 GPa for the steel, determine the stress in the steel and the maximum stress in the concrete. **(18)**

3. (a) Find the algebraic expression for the deflection of the beam as in Fig. 3(a). **(15)**

   (b) State the Castigliano's theorem for the deflection of a structural member caused by any external force. Hence, find the deflection at the free end of the beam in Fig. 3(a) by using this theorem. **(20)**

4. (a) A 12 kN.m torque is applied to the free end of a steel shaft as in Fig. 4(a). The angle of rotation of the shaft is to be limited to 3°. Find the smallest diameter of the shaft that can be used and the maximum shear stress in the shaft. Use G = 83 GPa for steel. **(17)**

   (b) Derive the formula for deflection of a closely coiled helical spring. Hence, show that the deflection due to direct shear is negligible compared to that due to torsion if the above is a light duty spring. **(18)**

Contd ..... P/2

## ME 243/ChE

### SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Assume reasonable value for any missing data. Symbols have their usual meanings.

5. (a) Compute the shearing stress in the pin at B for the member supported as shown in Fig. for Q. 5(a) below. The pin diameter is 20 mm. **(15)**

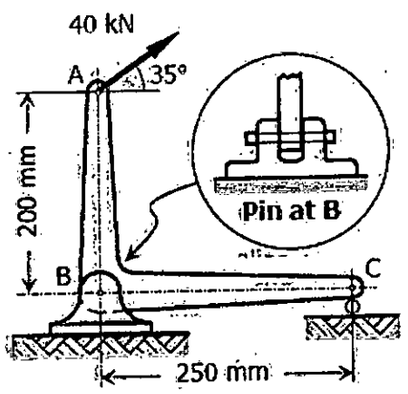


Fig. for Q.5 (a)

(b) The horizontal rigid beam ABCD shown in Fig. for Q. 5(b), is supported by vertical bars BE and CF and is loaded by vertical forces $P_1$ = 400 kN and $P_2$ = 360 kN acting at points A and D, respectively. Bars BE and CF are made of steel (E = 200 GPa) and have cross-sectional areas $A_{BE}$ = 11,100 mm$^2$ and $A_{CF}$ = 9,280 mm$^2$. The distances between various points on the bars are shown in the figure. Determine the vertical displacements of point A and D. **(20)**

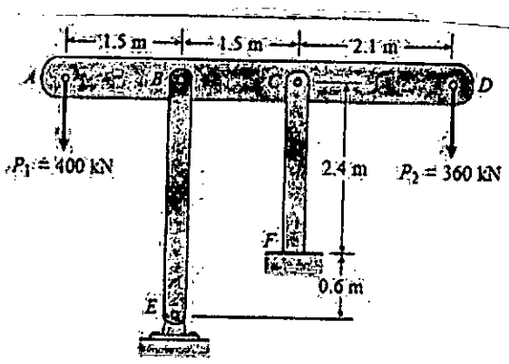


Fig. for Q.5 (b)

6. (a) The assembly in Fig. for Q. 6(a) below consists of a light rigid bar AB, pinned at O, that is attached to the steel and aluminum rods. In the position shown, bar AB is horizontal and there is a gap, Δ = 5 mm, between the lower end of the steel rod and its pin support at C. Compute the stress in the aluminum rod when the lower end of the steel rod is attached to its support. **(20)**

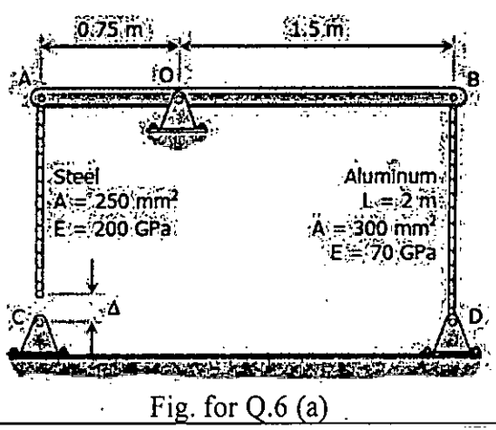


Fig. for Q.6 (a)

Contd ..... P/3

**ME 243/ChE**

**Contd ... Q. No. 6**

(b) A rigid bar of negligible weight is supported as shown in Fig. for Q. 6(b). If W = 80 kN, compute the temperature change that will cause the stress in the steel rod to be 55 MPa. Assume the coefficients of linear expansion are 11.7 μm/(m.°C) for steel and 18.9 μm/(m.°C) for bronze. **(15)**

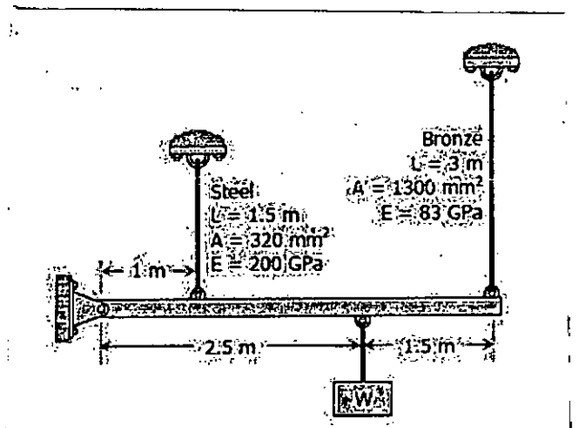


Fig. for Q.6 (b)

7. (a) The stress element shown in Fig. for Q. 7(a) has $\sigma_x$ = 90 MPa, $\sigma_y$ = – 60 MPa and $\tau_{xy}$ = 20 MPa. Determine the principal stresses, maximum shearing stress and the planes on which these stresses act. Solve the problem using Mohr's circle and show your answers on a complete sketch of a differential element. **(20)**

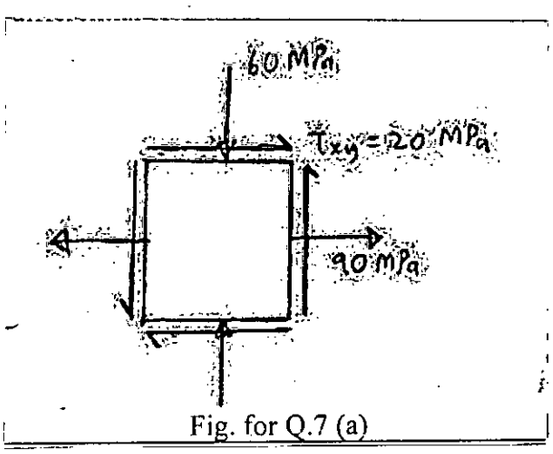


Fig. for Q.7 (a)

(b) The cylinder of a hydraulic press has an internal diameter of 300 mm and is to be designed to withstand an internal pressure of 15 MPa without the material being stressed over 25 MPa. Determine the thickness of the metal and the hoop stress on the outer side of the cylinder. **(15)**

Contd ..... P/4

## ME 243/ChE

8. (a) An aluminum (E = 70 GPa) column built into the ground shown in Fig. for Q. 8(a) has length, L = 2.2 m, and is under axial compressive load P. The dimensions of the cross-section are b = 210 mm and d = 280 mm. Find: **(20)**

(i) The critical load to buckle the column.

(ii) If the allowable compressive stress in the Aluminum is 240 MPa, is the column more likely to buckle or yield?

(iii) If the factor of safety is F.S = 1.95, what is the allowable buckling load?

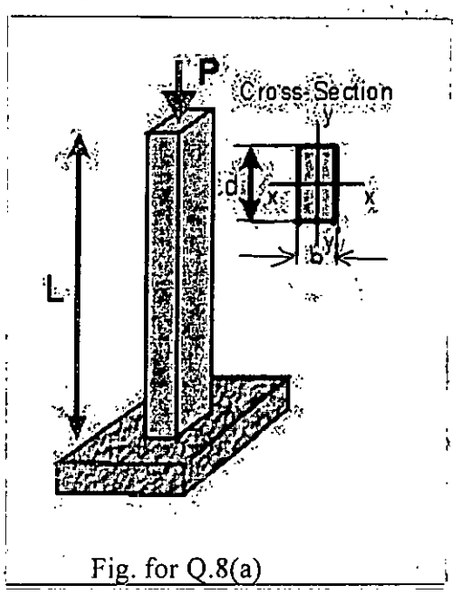


Fig. for Q.8(a)

(b) Find the largest possible diameter of a rod subjected to a bending moment of 3 kN.m and a twisting moment of 1.8 kN.m according to the following theories of failure, taking yield strength as 420 MPa and factor of safety as 3. **(15)**

(i) Normal stress theory (ii) Shear stress theory

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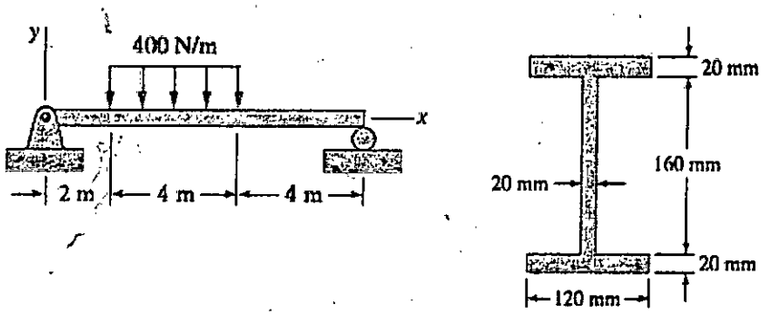


Fig. for Q-1(a)

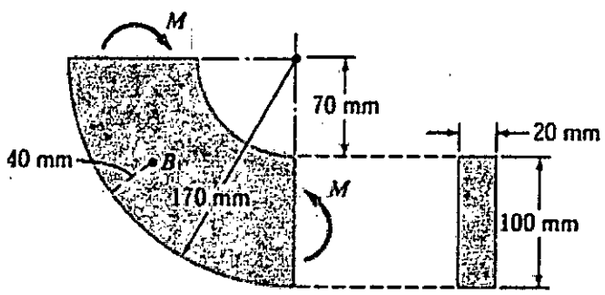


Fig. for Q-2(a)

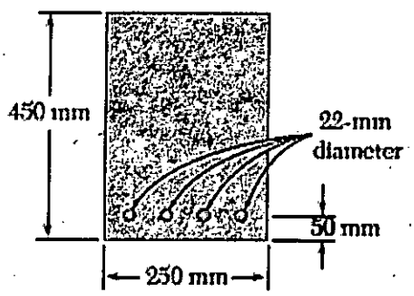


Fig. for Q-2(b)

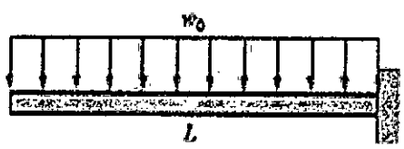


Fig. for Q-3(a)

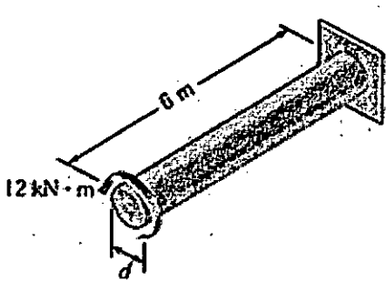


Fig. for Q-4(a)