

1-1

**University of Asia Pacific**  
**Department of Civil Engineering**  
**Final Examination, Fall 2024**  
**Program: B.Sc. in Civil Engineering**  
**1<sup>st</sup> Year 1<sup>st</sup> Semester**

Course Title: Basic Electrical and Electronic Engineering  
Time: 3 hours

Course Code: ECE 101  
Credit Hour: 3.00

Full Marks: 150

**Answer all the questions**

**QUESTION 1 [25 MARKS]**

[CO1]

Solve the power of the 15-ohm resistor in the circuit given in **Figure 1**.

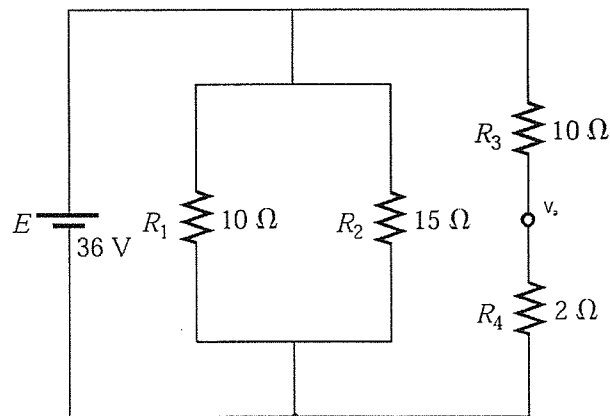


Figure 1

**QUESTION 2 [25 MARKS]**

[CO1]

**Construct** a simplified presentation of the circuit given in **Figure 2** with respect to 4 kilo-ohm resistor. From that simplified circuit, containing a source and a resistor, calculate- the power absorbed by the 4 kilo-ohm resistor.

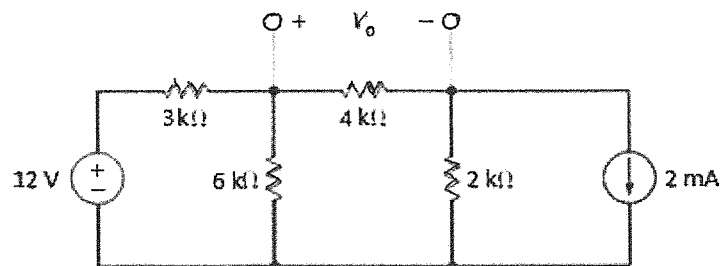


Figure 2

**QUESTION 3 [25 MARKS]**

[CO3]

For the given electromagnet in the picture of **Figure 3**,

- a. **Find** the Flux density. [15]
- b. Redraw the electromagnet and **show** a few flux lines with directions. [5]
- c. **Show** names of the poles on the picture. [5]

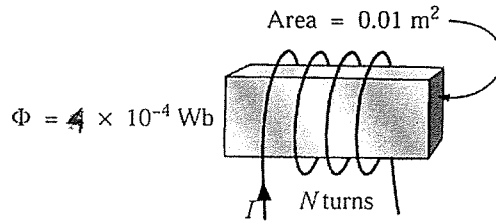


Figure 3

**QUESTION 4 [75 MARKS] (answer any one from 'a' or 'b')**

[CO2]

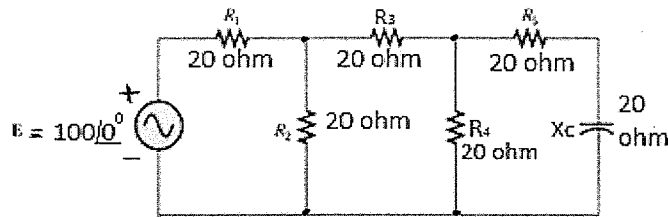


Figure 4

- a) From **Figure 4**, solve-
  - i. Power and power factor of the R-C branch. [25]
  - ii. Power and power factor w.r.t the source. [25]
  - iii. And **show** Wave forms of source Voltage and the corresponding Current. [25]

**OR**

- b) From **Figure 5**, solve-
  - i. Power and power factor of the R-C branch [not the R-L-C branch]. [25]
  - ii. Power and power factor w.r.t the source. [25]
  - iii. And **show** Wave forms of source Voltage and the corresponding Current. [25]

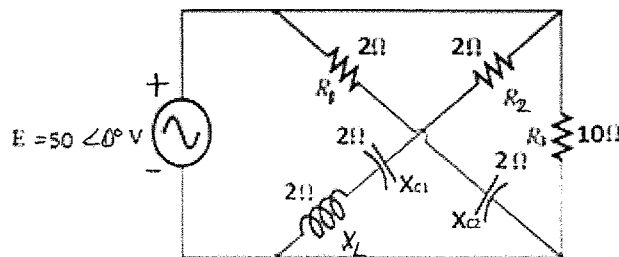


Figure 5

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**Program: B.Sc. in Civil Engineering**  
**1<sup>st</sup> Year 1<sup>st</sup> Semester**

Course Title: Mathematics-I  
Time: 3 hours

Credit Hour: 3.00

Course Code: MTH 101  
Full Marks: 150

There are eight questions. Answer **any six** including **QUESTION 1, QUESTION 2, QUESTION 3 and QUESTION 4.**

**QUESTION 1 [25 MARKS]**

- a. Investigate the continuity and differentiability of the function  $f(x)$  at  $x = 0$  [15]

$$\text{where, } f(x) = \begin{cases} -x & ; x \leq 0 \\ x & ; 0 < x < 1 \\ 1 - x & ; x \geq 1 \end{cases}$$

- b. Does  $\lim_{x \rightarrow 1} f(x)$  exist? Where,  $f(x) = \begin{cases} x^2 - 1 & ; x < 1 \\ 2 & ; x = 1 \\ x^2 + 1 & ; x > 1 \end{cases}$  [10]

**QUESTION 2 [25 MARKS]**

Integrate the following:

i)  $\int \frac{x+1}{x^2-7x+10} dx$

ii)  $\int \frac{\cos x}{\sin x + 2 \cos x} dx$

iii)  $\int e^{2x} \cos 3x dx$  and iv)  $\int \frac{\tan x \sec^2 x}{(a^2 + b^2 \tan^2 x)^2} dx$ .

**QUESTION 3 [25 MARKS]**

- a. Compute the area of the surface generated by revolving the curve [15]

$$x^2 + y^2 = 4 \text{ about the } X \text{ axis between } x = -1 \text{ and } x = 1.$$

- b. The circle  $x^2 + y^2 = r^2$  revolves around the  $x$ -axis. Evaluate the volume of the whole surface generated. [10]

**QUESTION 4 [25 MARKS]**

- a. Compute the area above the  $X$ -axis, enclosed by the parabola  $y^2 = 4x$  and the circle  $x^2 + y^2 = 8x$ . [15]

- b. Find the length of the arc of the Cardioid  $r = a(1 - \cos \theta)$ . [10]

**QUESTION 5 [25 MARKS]**

- a. Express the integral  $\int_0^1 \frac{dx}{\sqrt{1-x^5}}$  in terms of the Beta function, also verify that [15]  
 $\int_0^{\frac{\pi}{2}} \sin^6 \theta \cos^3 \theta d\theta = \frac{2}{63}$
- b. Evaluate  $\int_0^{\infty} e^{-x^2} dx$  with the help of the Gamma function. [10]

**OR**

**QUESTION 6 [25 MARKS]**

- a. Define Beta and Gamma functions. Evaluate the improper integral [15]  
 $\int_0^{\infty} e^{-x^2} x^7 dx$ .
- b. Prove that  $\int_0^{\frac{\pi}{2}} \sin^m x \cos^n x dx = \frac{\Gamma(\frac{m+1}{2}) \Gamma(\frac{n+1}{2})}{2\Gamma(\frac{m+n+2}{2})}$ . [10]

**QUESTION 7 [25 MARKS]**

- a. If  $y = \sin^{-1} x$ , applying Leibniz's theorem, show that [15]  
 $(1-x^2)y_{n+2} - (2n+1)xy_{n+1} - n^2y_n = 0$ .
- b. Express the 5<sup>th</sup> order Maclaurin's polynomials of  $f(x) = \ln(1+x)$ . [10]

**OR**

**QUESTION 8 [25 MARKS]**

- a. If  $y = \tan^{-1} x$ , applying Leibniz's theorem, show that [15]  
 $(1+x^2)y_{n+2} + 2(n+1)xy_{n+1} + n(n+1)y_n = 0$ .
- b. Compute the first six Taylor polynomials of  $f(x) = \ln x$  at  $x = 2$ . [10]

**University of Asia Pacific**  
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**Program: B.Sc. in CE**  
**1<sup>st</sup> Year 1<sup>st</sup> Semester**

Course Title: Physics I  
Time: 3.00 Hours

Credit Hour: 3.00

Course Code: PHY 101  
Full Marks: 150

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There are eight questions. Answer any six, including QUESTION 1, QUESTION 2, QUESTION 3, and QUESTION 4

**QUESTION 1 [25 MARKS]**

- a. Define cantilever and beam. Show that depression  $y = Wl^3/3YI_g$ , where the terms have their usual meanings. [05+10]
- b. A uniform rod of length 1.5 m is clamped horizontally at one end. A weight of 0.5 kg is attached at the free end. Calculate the depression at the midpoint of the rod. The diameter of the rod is 0.06 m. ( $Y = 10^{-10}N/m^2$ ) [10]

**QUESTION 2 [25 MARKS]**

- a. Define Bernoulli's theorem and fluid. Show that for a liquid in streamline motion [05+10]
- $$\frac{P}{\rho} + gh + \frac{v^2}{2} = \text{constant}$$
- where the symbols have their usual meanings.
- b. Four equal drops of water (surface tension  $T$ ), each of radius  $r$ , are falling through air (viscosity  $\eta$ ) with a steady velocity  $v$ . If the four drops coalesce to form a bigger drop, (i) compute the energy released and (ii) find the new velocity of fall. [10]

**QUESTION 3 [25 MARKS]**

- a. Explain the Doppler effect of sound. Find out the apparent pitch of sound when the source moves towards and away from the stationary observer. [05+10]
- b. The apparent frequency of the whistle of an engine changes in the ratio 6:5 as the engine passes a stationary observer. If the velocity of sound is 352 m/sec, calculate the velocity of the engine. [10]

**QUESTION 4 [25 MARKS]**

- a. Explain Lissajous' figures. Prove that  $y = A \sin(\omega t + \phi)$  from the composition of two simple motions in a straight line, where the terms have their usual meanings. [05+10]

- b. Two simple harmonic motions acting simultaneously on a particle are given by the equations  $y_1 = 2 \sin(\omega t + \pi/6)$  and  $y_2 = 3 \sin(\omega t + \pi/3)$ . Calculate (i) amplitude, (ii) phase constant, and (iii) time period of the resultant vibration. [10]

**QUESTION 5 [25 MARKS]**

- a. Describe the production of Newton's rings by monochromatic light. Show that [05+10]

$$r^2 = n\lambda R$$

for Newton's dark ring, where the terms have their usual meanings.

- b. A plano-convex lens of radius 300 cm is placed on an optically flat glass plate and is illuminated by monochromatic light. The diameter of the 8<sup>th</sup> dark ring in the transmitted system is 0.72 cm. Calculate the wavelength of light used. [10]

OR

**QUESTION 6 [25 MARKS]**

- a. State and explain Brewster's and Malus' law for a polarized light. [15]
- b. If the plane of vibration of the incident beam makes an angle of 30° with the optic axis, compare the intensities of extraordinary and ordinary light. [10]

**QUESTION 7 [25 MARKS]**

- a. State the 1<sup>st</sup> law and 2<sup>nd</sup> laws of thermodynamics. Distinguish between Carnot's engine and refrigerator, and also prove that the efficiency of the refrigerator is more than hundred percent. [05+10]
- b. A Carnot engine is operated between two reservoirs at temperatures of 450 K and 350 K. If the engine receives 1000 calories of heat from the source in each cycle, calculate the amount of heat rejected to the sink in each cycle. Calculate the efficiency of the engine and the work done by the engine in each cycle. (1 calorie = 4.2 joules) [10]

OR

**QUESTION 8 [25 MARKS]**

- a. State four postulates of the kinetic theory of gases. Prove that  $C = \sqrt{\frac{3P}{\rho}}$ , where [05+10]  
the symbols have their usual meaning.
- b. At what Celsius temperature will oxygen molecules have the same root mean square velocity as that of hydrogen molecules at -100°C? [10]

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**1<sup>st</sup> Year 1<sup>st</sup> Semester**

Course Title: Introduction to Civil and Environmental Engineering  
Time: 2 hours

Credit Hour: 2

Course Code: CE 107  
Full Marks: 100

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**Answer all the questions**

**QUESTION 1 [15 MARKS]**

- a. Define biodiversity hotspot. Explain why we need to protect biodiversity. [3+3]
- b. Discuss the types of biodiversity and identify the direct benefits of biodiversity. [4+5]

**QUESTION 2 [15 MARKS]**

- a. Just a few months ago, UAP area was surrounded by stagnant water with almost entire city flooded. Which type of flood do you believe it was? Investigate the management approach against this flood. [10]
- b. Explain what factors make Bangladesh more vulnerable during flood. [5]

**QUESTION 3 [15 MARKS]**

- a. Define ecology and ecosystem. Describe the purposes of studying ecology. [4+6]
- b. Explain ecosystem hierarchy in brief. [5]

**QUESTION 4 [19 MARKS]**

- a. Classify field survey based on the instruments used and discuss any two of them. [3+4]
- b. Differentiate between national highway and regional highway. [4]
- c. Discuss on different types of loads that can act on a structure. [8]

**QUESTION 5 [16 MARKS]**

- a. Discuss the purpose of soil test and site classification. [6]
- b. Demonstrate the components of soil test and discuss them in brief. [10]

**QUESTION 6 [10 MARKS]**

- A five-storied residential building is to be constructed. Estimate the total construction cost as per the PWD schedule. The particulars of the building are as follows: [20]

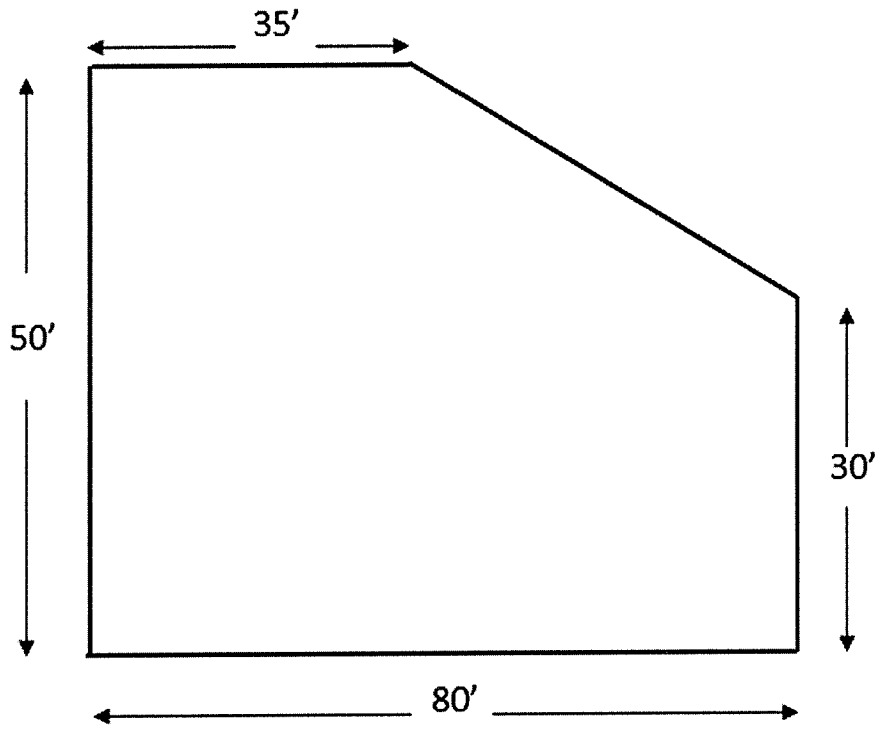


Figure 1

| Serial No | Particulars                          | Specification                                   |
|-----------|--------------------------------------|---|
| 1         | Land Size                            | Determine from plot layout as shown in Figure 1 |
| 2         | Building type                        | Residential (Economy)                           |
| 3         | Allowable Bearing Capacity ( $q_a$ ) | 4 ksf   |
| 4         | Floor Level                          | Five  |
| 5         | Plinth Area                          | 70 % of land size                               |
| 6         | Construction Material                | 24 MPa, RCC Structure 1: 1.5 : 3 (Stone Chips)  |
| 7         | Ground Floor                         | Car Parking                                     |
| 8         | Rooftop RCC water tank               | 1500 Gallon                                     |
| 9         | Structure type                       | RCC Frame Structure                             |
| 10        | Underground water reservoir          | 4000 Gallon                                     |
| 11        | Boundary wall                        | RCC Frame                                       |
| 12        | Contingency Cost                     | Consider 10 % for this building                 |

**Annexure: PWD SCHEDULE**

**1. Foundation Cost upto PL (per m<sup>2</sup> of Plinth Area)**

| Storey | q <sub>a</sub> = 2 ksf | q <sub>a</sub> = 2.50 ksf | q <sub>a</sub> = 3.0 ksf | q <sub>a</sub> = 3.5 ksf | q <sub>a</sub> = 4.0 ksf | q <sub>a</sub> = 4.5 ksf | q <sub>a</sub> = 5.0 ksf |
|--------|------------------------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1      | 3982                   | 3875                      | 3811                     | 3769                     | 3740                     | 3718                     | 3702                     |
| 2      | 4684                   | 4381                      | 4199                     | 4080                     | 3997                     | 3936                     | 3830                     |
| 3      | 5591                   | 5036                      | 4702                     | 4482                     | 4329                     | 4217                     | 4133                     |
| 4      | 6566                   | 5811                      | 5296                     | 4958                     | 4723                     | 4551                     | 4421                     |
| 5      | 8001                   | 6774                      | 6035                     | 5550                     | 5212                     | 4965                     | 4778                     |
| 6      | 9495                   | 7851                      | 6862                     | 6213                     | 5759                     | 5429                     | 5178                     |
| 7      | 10961                  | 8908                      | 7673                     | 6862                     | 6296                     | 5883                     | 5571                     |
| 8      |                        | 10043                     | 8544                     | 7560                     | 6873                     | 6371                     | 5992                     |
| 9      |                        | 11252                     | 9471                     | 8302                     | 7487                     | 6891                     | 6441                     |
| 10     |                        | 12529                     | 10451                    | 9088                     | 8136                     | 7441                     | 6915                     |

**2. Superstructure Cost (per m<sup>2</sup> of Plinth Area)**

| Building Category |                       |  |          |          |  |          |          |  |          |          |  |          |          |
|-------------------|-----------------------|--|----------|----------|--|----------|----------|--|----------|----------|--|----------|----------|
|                   |                       | Non-Residential<br>(fc=19-21 MPa, Brick Chips) |          |          | Residential<br>(fc=19-21 MPa, Brick Chips) |          |          | Non-Residential<br>(fc=22-25 MPa, Stone Chips) |          |          | Residential<br>(fc=22-25 MPa, Stone Chips) |          |          |
| Level             | Floor                 | Economy  | Standard | Superior | Economy                                    | Standard | Superior | Economy  | Standard | Superior | Economy                                    | Standard | Superior |
| 0                 | GF Park               | 5449   | 5812     | 6538     | 5634                                       | 6010     | 6761     | 5922   | 6317     | 7107     | 6124                                       | 6532     | 7349     |
| 0A                | Habitation            | 8545   | 9601     | 12674    | 8837                                       | 9929     | 13106    | 9020   | 10135    | 13378    | 9631                                       | 10792    | 14274    |
| 1                 | 1 <sup>st</sup> Floor | 8242   | 9360     | 12224    | 8523                                       | 9576     | 12640    | 8699   | 9776     | 12903    | 9289                                       | 10409    | 13767    |
| 2                 | 2 <sup>nd</sup> Floor | 8365   | 9399     | 12407    | 8651                                       | 9720     | 12830    | 8830   | 9921     | 13096    | 9568                                       | 10565    | 14180    |
| 3                 | 3 <sup>rd</sup> Floor | 8491   | 9540     | 12593    | 8780                                       | 9866     | 13023    | 8962   | 10070    | 13293    | 9855                                       | 10723    | 14606    |
| 4                 | 4 <sup>th</sup> Floor | 8618   | 9683     | 12782    | 8912                                       | 10014    | 13218    | 9097   | 10221    | 13492    | 10151                                      | 10884    | 15044    |
| 5                 | 5 <sup>th</sup> Floor | 8748   | 9829     | 12974    | 9046                                       | 10154    | 13416    | 9233   | 10374    | 13694    | 10455                                      | 11046    | 15495    |
| 6                 | 6 <sup>th</sup> Floor | 8835   | 9927     | 13104    | 9136                                       | 10265    | 13550    | 9326   | 10478    | 13831    | 11030                                      | 11158    | 15960    |

3. Boundary Wall: Tk.3500/m
4. External Water Supply: Tk.60.00/gallon
5. Gas Connection:
  - GF: Tk.260/sqm
  - Other floors: Tk.100/sqm
6. Internal Electrification:
  - (i) Residential Building
    - Economy: Tk.1030 /sqm
    - Standard: Tk.1290 /sqm
    - Superior: Tk.1550 /sqm
  - (ii) Non- Residential Building
    - Economy: Tk.775 /sqm
    - Standard: Tk.970 /sqm
    - Superior: Tk.1160 /sqm
7. Internal Sanitary and Water Supply:
  - (i) Residential Building
    - Economy: Tk. 475 /sqm
    - Standard: Tk.715 /sqm
    - Superior: Tk. 1070 /sqm
  - (ii) Non-Residential Building
    - Economy: Tk.360 /sqm
    - Standard: Tk.540 /sqm
    - Superior: Tk.800 /sqm
8. Floor Finish Work: Tk.1000.00/ sqm
9. Roof top RCC water Tank: Tk.85.00/gallon

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**1<sup>st</sup> Year 1<sup>st</sup> Semester**

Course Title: History of Bangladesh Independence, Society and Culture    Course Code: HSS 105  
Time: 3 hours    Credit Hours: 03    Full Marks: 150

Answer the following questions.  
Use separate answer scripts for Part-A and Part-B.  
Figures in the right margin indicate marks.  
**You MUST answer each part of a question consecutively.**

**Part A (Question 1-4)**

**QUESTION 1 [30 MARKS]**

Discuss the Six-point Programme of 1966. [30]

**QUESTION 2 [30 MARKS]**

Write an article on the Liberation War of Bangladesh. [30]

**QUESTION 3 [15 MARKS]**

Discuss the first phase of the language movement of 1952. [15]

**OR**

**QUESTION 4 [15 MARKS]**

Write a short note on the Operation Searchlight. [15]

**[Please turn over]**

**Part B (Question 5-8)**

**QUESTION 5 [30 MARKS]**

- a. Define socialization. [8]
- b. Briefly discuss the agencies of socialization. [22]

**QUESTION 6 [30 MARKS]**

- a. Define social stratification. [8]
- b. What are the systems of social stratification? Name them. Briefly discuss the systems of social stratification. [22]

**QUESTION 7 [15 MARKS]**

Define the types of social mobility with examples. [15]

OR

**QUESTION 8 [15 MARKS]**

Define the non-material elements of a culture. [15]

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Course Title: Engineering Mechanics  
 Time: 3 hours

Credit Hour: 3.00

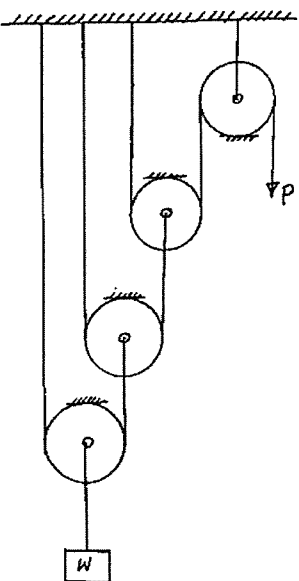
Course Code: CE 101(OBE)  
 Full Marks: 150

**Answer all the questions.**

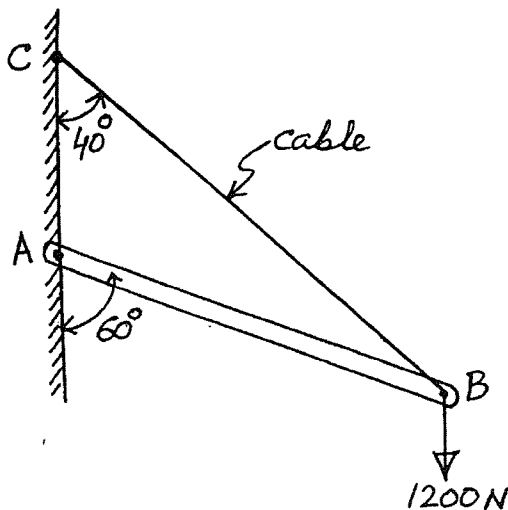
**PART A**

**QUESTION 1 [25 MARKS]**

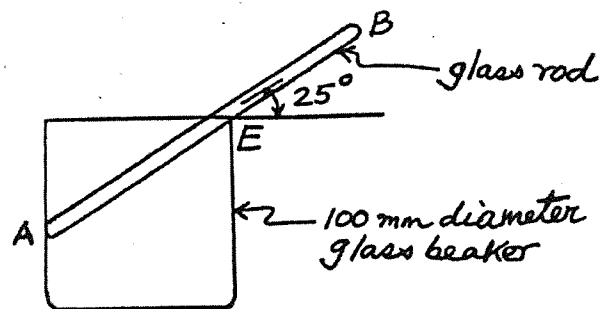
- a. Using the system of frictionless pulleys a weight  $W$  has to be lifted by applying a pulling force of  $P$  as shown in **Figure 1**. Calculate the value of  $W$  if  $P = 50$  N. [5]
  
- b. A bar of weight  $400$  N is hinged to a vertical wall at  $A$  and has been supported by a cable as shown in **Figure 2**. The length of the bar  $AB$  is  $10$  m. Determine the tension in the cable  $BC$  and components of pin reactions at  $A$ . [12]
  
- c. A glass rod  $AB$  of weight  $3$  N is placed in a glass beaker in a position of equilibrium as shown in **Figure 3**. Considering all the surfaces to be smooth, determine the length of the glass rod. Also find the reactions at contact points  $A$  and  $E$ . [8]



**Figure 1**



**Figure 2**



**Figure 3**

**QUESTION 2 [25 MARKS]**

- a. The frame shown in **Figure 4** consists of two vertical members AE and BD, a horizontal member CD and an inclined member DE. All the members have been assumed to be weightless.
- Show the two-force member(s).
  - Calculate the components of pin reactions at B.
  - Determine the force in the two-force member(s).

[11]

- b. For the truss shown in **Figure 5**, find the force in the members *bi*, *dh*, *dg* and *fg*.

[8]

- c. A table supports a load of 100 N at point D as shown in **Figure 6**. The weight of the triangular top is 200 N. Length of each side of the table is 900 mm. Determine the reactions at the supporting legs at A, B and C.

[6]

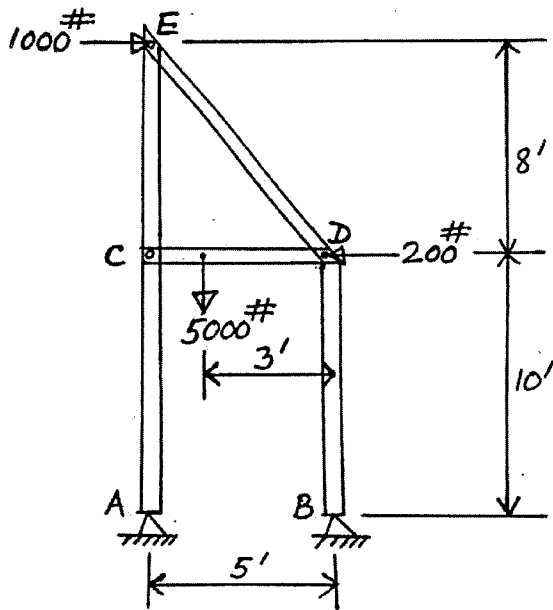


Figure 4

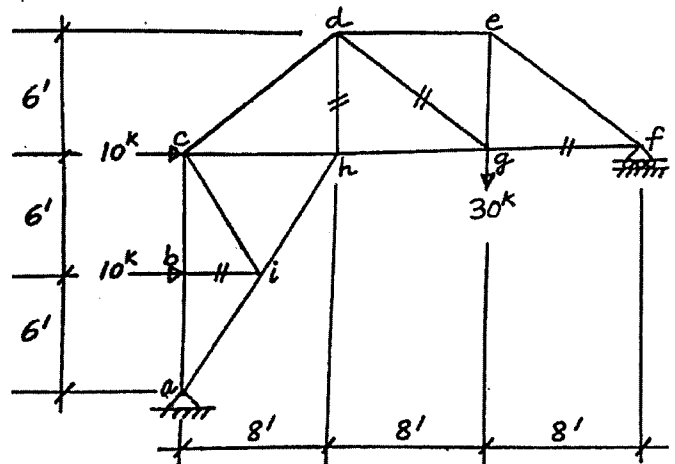


Figure 5

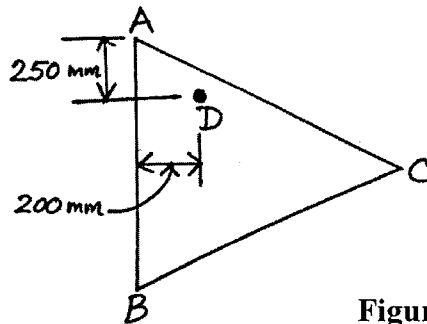


Figure 6

**QUESTION 3 [25 MARKS]**

- a. Body A weighing 200 N rests over body B weighing 400 N as shown in **Figure 7**. The coefficient of static friction for all contact surfaces is 0.5. Calculate the value of the force P that will cause body B to have impending motion toward right.

[7]

- b. Body A in **Figure 8** weighs 150 lb. The coefficient of static friction between the body and the inclined plane is 0.4, and the coefficient of static friction between the rope and the drums is 0.3. Determine the value of W when the motion of the body A impends up the plane.

[11]

- c. A cylindrical oil drum of diameter 800 mm is pulled by a force Q as shown in **Figure 9**. The drum weighs 2000 N. The value of coefficient of static friction for all surfaces is 0.5. Determine the magnitude of the force Q when the drum just starts spinning.

[7]

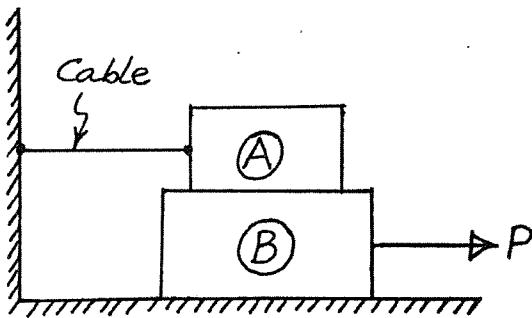


Figure 7

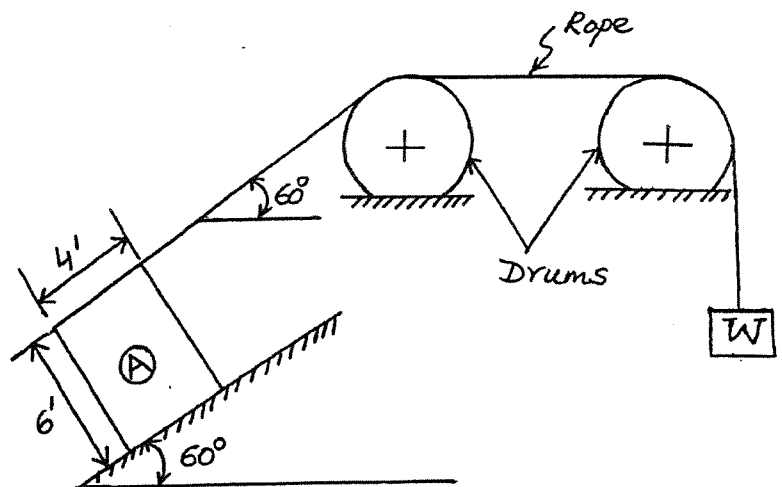


Figure 8

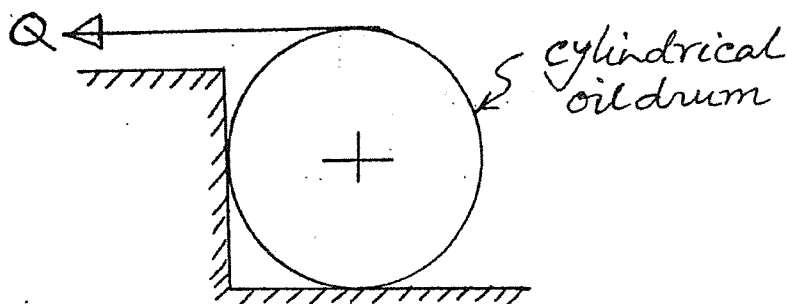


Figure 9

PART B

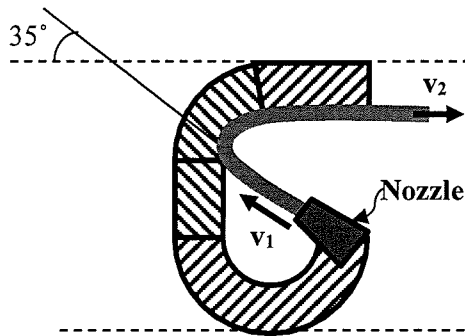


Figure 10

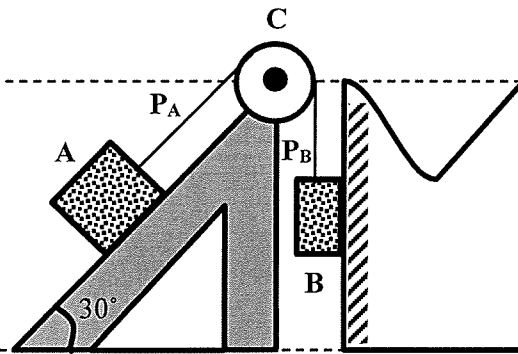


Figure 11

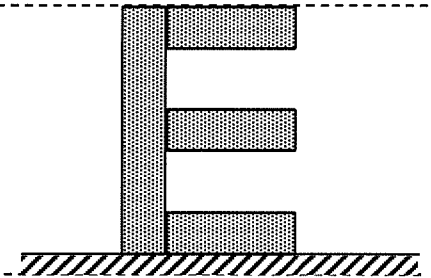


Figure 12

QUESTION 4 [25 MARKS]

- a. A jet of steam, flowing at the rate of  $W = 2.1$  lb. per sec., issues from a nozzle with a velocity of  $v_1 = 650$  fps and at an angle of  $35^\circ$  with horizontal as shown in **Figure 10**. It enters a fixed blade and is turned through an angle of  $145^\circ$  before it is discharged horizontally. Assume that the passage of steam across the blade is frictionless.
- (i) Determine the horizontal and vertical components of the force exerted upon the fixed blade.
  - (ii) Determine the resultant force.
  - (iii) Determine the angle of reaction.

[12]

- b. In **Figure 11** a body **A** weighing  $W_A = 50$  lb. is on a plane inclined at an angle of  $\beta = 30^\circ$ . The inclined surface is frictionless. A cable attached to this body passes over a stationary member **C**, for which the coefficient of friction is  $f_c = 0.22$ . At the other end of the cable is suspended a body **B** weighing  $W_B = 120$  lb. Body **B** touches a surface which can generate a friction force of 20 lb. Calculate the tensions  $P_A$  and  $P_B$  in the cable and what are the speed and direction of the bodies after they moved 10 ft from the rest. The weight of the cable is negligible.

[13]

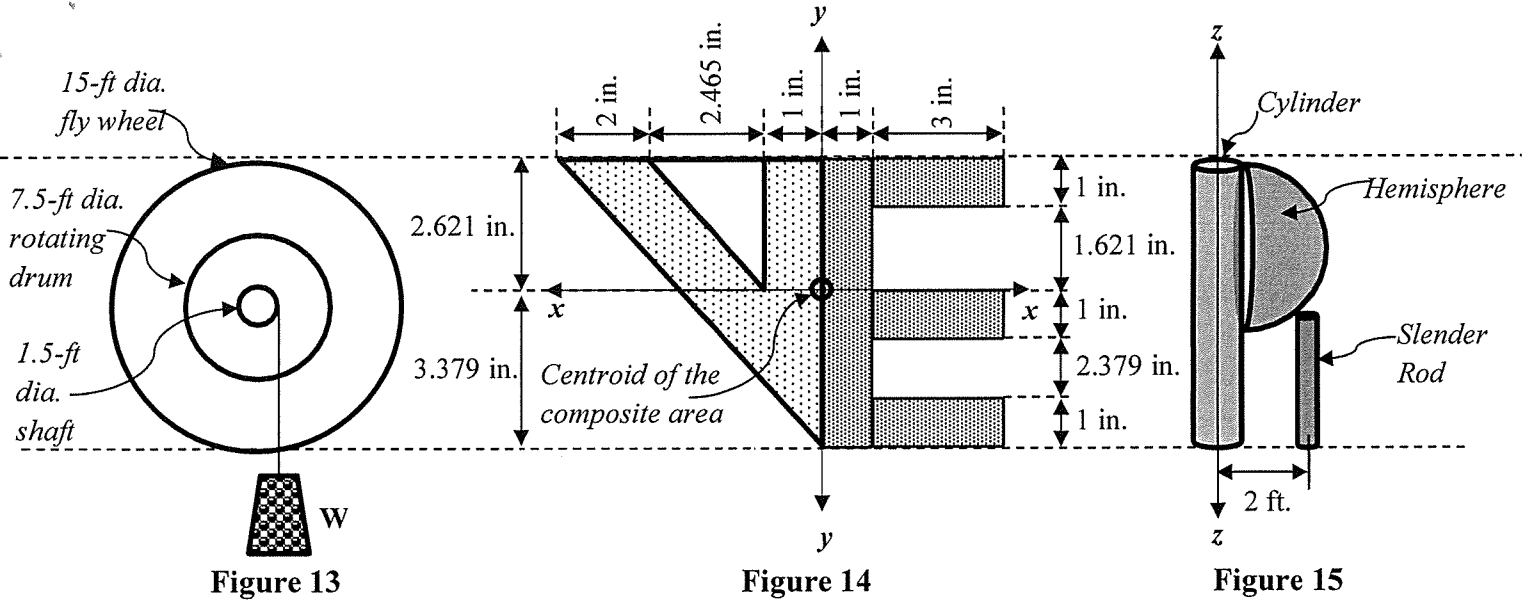


Figure 13

Figure 14

Figure 15

**QUESTION 5 [25 MARKS]**

- a. The body shown in **Figure 12** moves according to the acceleration  $a = 5t^{\frac{1}{3}} \text{ fps}^2$ . When time,  $t = 0 \text{ sec.}$ , velocity  $v_0 = 6 \text{ fps}$  and displacement  $s_0 = 0 \text{ ft.}$  Determine the displacement that occurs from time  $t = 4 \text{ sec.}$  to  $t = 10 \text{ sec.}$
- b. A weight of  $W = 300 \text{ lb.}$  is supported from a cable which is wound about a 7.5 ft. dia. rotating drum as shown in **Figure 13**. An 15 ft. dia. flywheel turns with the drum. The total weight of the rotating part is  $W_R$  and the radius of gyration is 4.5 ft. While the weight travels 50 ft. vertically downward, the speed of the rotating parts changes from 15 rpm to 100 rpm. The frictional force in the bearings acting tangentially to the 1.5 ft. dia. shaft is 90 lb. Determine the total weight of the rotating part  $W_R$ .

[11]

[14]

**QUESTION 6 [25 MARKS]**

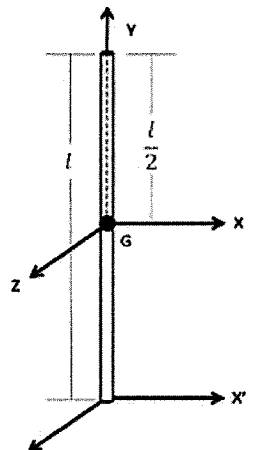
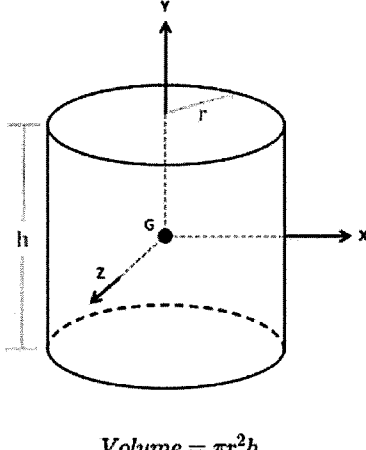
- a. Compute minimum moment of inertia  $I_{\min}$  and maximum moment of inertia  $I_{\max}$  as well as angle of principal axis  $\theta$  of the composite area shown in **Figure 14**. (The centroidal axes are shown in the figure)
- b. Calculate the moment of inertia of the composite mass shown in **Figure 15** about Z axis. The dimensions and the unit weights of the masses are shown below.

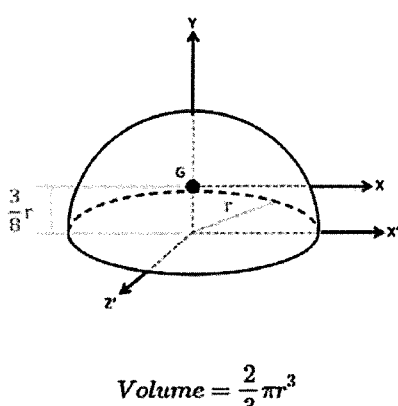
[14]

[11]

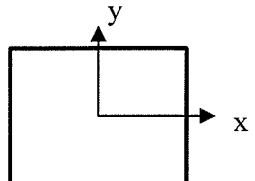
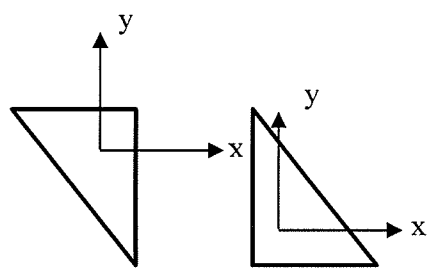
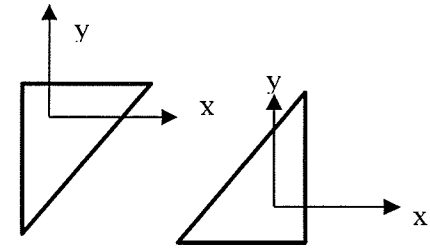
| Shape       | Dimension                      | Unit Weight            | Total Weight |
|-------------|--------------------------------|------------------------|--------------|
| Cylinder    | Radius = 0.5 ft; Height = 6 ft | 150 lb/ft <sup>3</sup> | -            |
| Hemisphere  | Radius = 3.5 ft                | 150 lb/ft <sup>3</sup> | -            |
| Slender Rod | Length = 3 ft                  | 490 lb/ft <sup>3</sup> | 1.85 lb      |

## ANNEXURE

|  |   |
|--|---|
| <p style="text-align: center;"><b>Slender Rod</b></p>  <div style="text-align: right; margin-top: 20px;"> <math display="block">I_{xx} = I_{zz} = \frac{1}{12} ml^2</math> <math display="block">I_{yy} = 0</math> </div> | <p style="text-align: center;"><b>Cylinder</b></p>  <p style="text-align: center;">Volume = <math>\pi r^2 h</math></p> <div style="text-align: right; margin-top: 20px;"> <math display="block">I_{xx} = I_{zz} = \frac{1}{12} m(3r^2 + h^2)</math> <math display="block">I_{yy} = \frac{1}{2} mr^2</math> </div> |
|--|---|

|   |   |  |
|---|---|--|
| <p style="text-align: center;"><b>Hemisphere</b></p>  <p style="text-align: center;">Volume = <math>\frac{2}{3} \pi r^3</math></p> | $I_{xx} = I_{zz} = \frac{83}{320} mr^2$ $I_{yy} = \frac{2}{5} mr^2$ | $I_{max} = \frac{1}{2} (I_x + I_y) + \sqrt{\left\{ \frac{(I_x - I_y)}{2} \right\}^2 + P_{xy}^2}$ $I_{min} = \frac{1}{2} (I_x + I_y) - \sqrt{\left\{ \frac{(I_x - I_y)}{2} \right\}^2 + P_{xy}^2}$ $\tan 2\theta_m = \frac{2P_{xy}}{(I_y - I_x)}$ |
|---|---|--|

**Table for product of inertia**

| Shape               | Rectangle   | Triangle   |   |
|---------------------|---|--|---|
| Axes                |  |  |  |
| $\overline{P_{xy}}$ | 0   | $-\frac{b^2 h^2}{72}$  | $\frac{b^2 h^2}{72}$  |