L-1/T-1/WRE **Date: 23/04/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **WRE 101** (Analytical Mechanics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Assume any reasonable value where necessary.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer **Q. No. 1** and any **TWO** from the rest.

1. (a) State the theorems of Pappus-Guldinus. What are the three different stabilities of equilibrium for potential energy, explain with example. **(3+8)**

(b) Deduce the following expression for the principal axes and principal moments of inertia: **(10+4)**

$$\left(I_{x'} - \frac{I_x + I_y}{2}\right)^2 + I_{x'y'}^2 = \left(\frac{I_x - I_y}{2}\right) + I_{xy}^2$$

How can you draw the Mohr's Circle from the above derived expression? Also explain the uses of Mohr's Circle.

(c) The cross section of a concrete dam is shown in Figure 1. For a 1.0 ft thick section of the dam determine (i) the magnitude and point of application of the resultant force due to self-weight exerted by the ground on the base AB of the dam, (ii) the resultant of the pressure forces exerted by the water on the face BC of the dam. The specific weights of concrete and water and 150 lb/ft^3 and 62.4 lb/ft^3, respectively. **(20)**

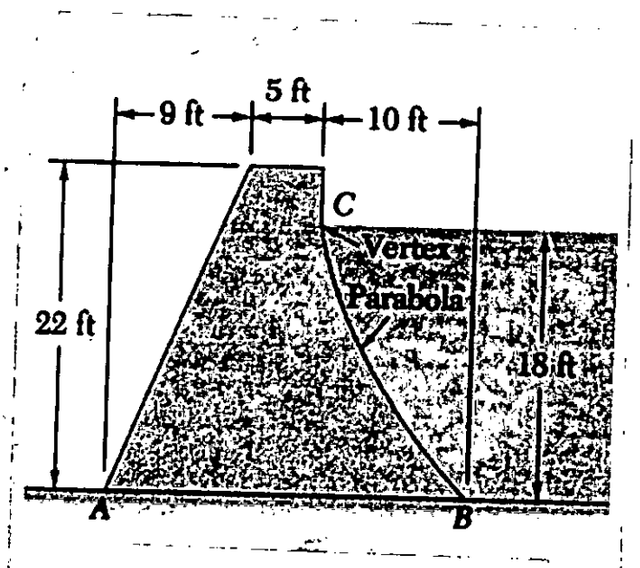

Figure 1 for Question 1(c)

Contd P/2

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2. (a) A brass collar with a length of 2.5" is mounted on an aluminum rod with a length of 4" (Figure 2). Locate the center of gravity of the composite body. (Specific weights: brass = 0.306 lb/in^3, aluminum = 0.101 lb/in^3. **(15)**

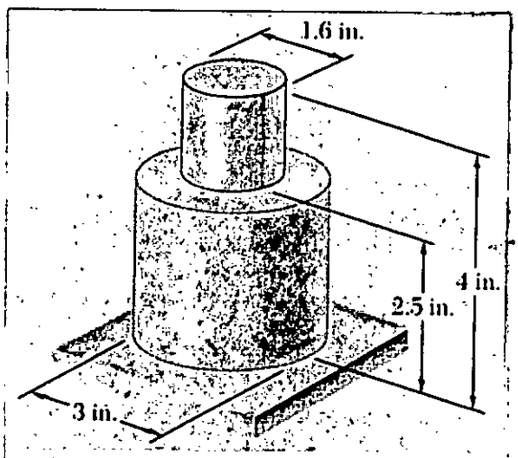

Figure 2 for Question 2(a)

(b) Using the method of virtual work, determine the magnitude of the couple M required to maintain the equilibrium of the mechanism shown in Figure 3. Given the value of l = 22 cm, P = 220 N, and $\theta = 30°$. **(15)**

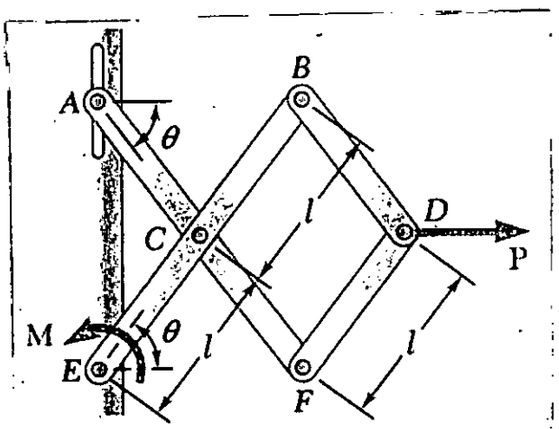

Figure 3 for Question 2(b)

3. (a) Determine the moment of inertia and the radius of gyration of the shaded area (Figure 4) with respect to x and y axis. **(15)**

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Contd... Q. No. 3(a)

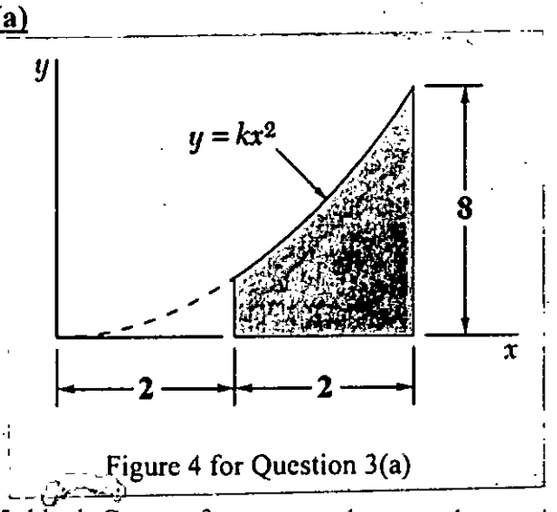

Figure 4 for Question 3(a)

(b) In Figure 5, block C starts from rest and moves down with a constant acceleration. Knowing that after block A has moved 1.5 ft, its velocity is 0.5 ft/s, determine (i) the acceleration of A and C, (ii) the change in velocity and the change in position of block B after 2.8 seconds. **(15)**

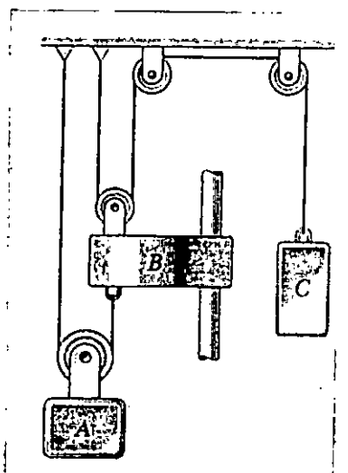

Figure 5 for Question 3(b)

4. (a) In Figure 6, a 12 kg package drops from a chute into a 28 kg cart with a velocity of 3.5 m/s. The cart is initially at rest and can roll freely. Determine (i) the final velocity of the card, (ii) the impulse exerted by the cart on the package, (iii) the fraction of the initial energy lost in the impact. **(15)**

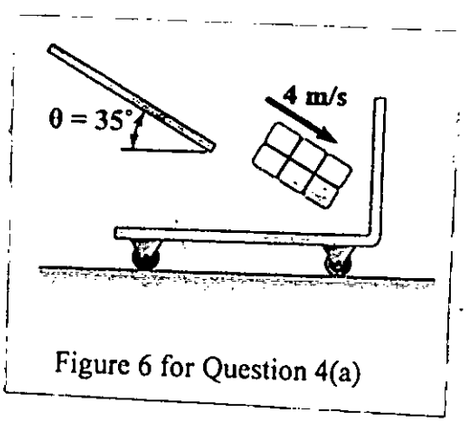

Figure 6 for Question 4(a)

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Contd... Q. No. 4

(b) In the engine system shown in Figure 7, the crank AB has a constant clockwise angular velocity of 1800 rpm. For the crank position shown, determine (i) the angular velocity of the connecting rod BD, (ii) the velocity of the piston P.

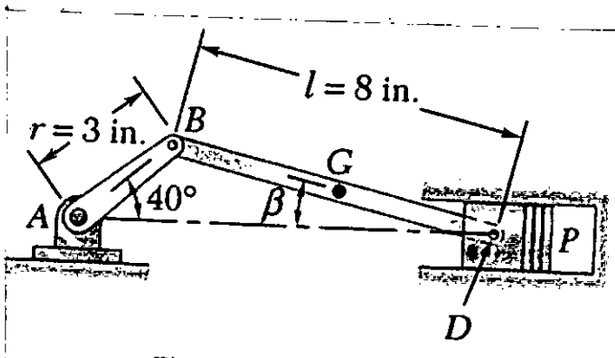

Figure 7 for Question 4(b)

SECTION – B

There are **FOUR** questions in this section. Answer **Q. No. 5** and any **TWO** from the rest.

5. (a) Determine the force in each member of the space truss and state if the members are in tension or compression. The truss is supported by ball-and-socket joints at A, B, and E. Set $F = \{-200i + 400j\}N$. **(15)**

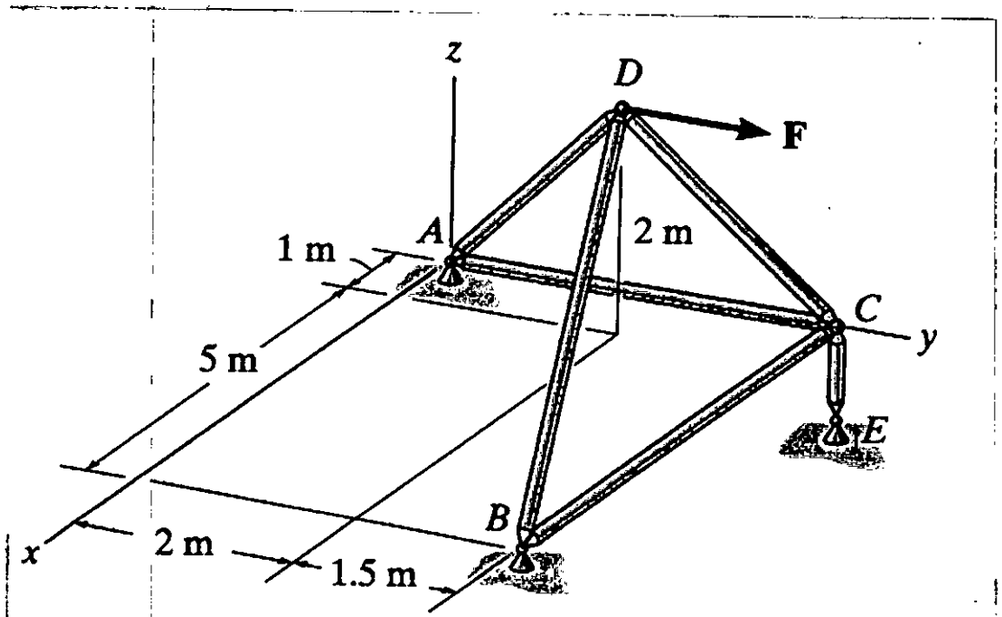

Figure 8 for question 5(a)

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Contd... Q. No. 5

(b) (i) Prove that a suspended cable under concentrated load follows the equation of a parabola. Find out the equation for the determination of the length of such a cable.

(ii) Show that the frictional relationship between the belt tensions follows the following equation. Where the coefficient of friction is μ. **(14)**

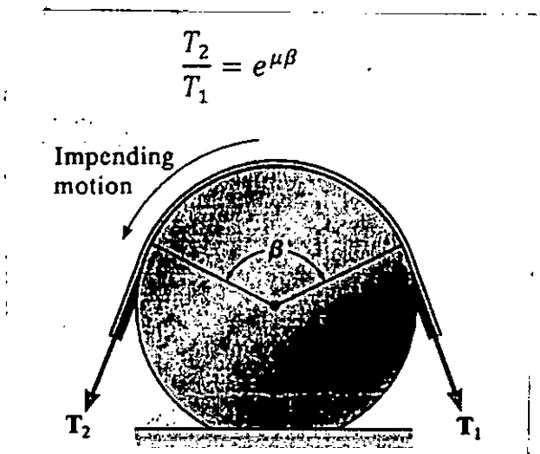

Figure 9 for question 5(b)

(c) With proper sketch discuss the characteristics of dry friction. **(6)**

6. (a) Determine the force in each member of the truss using the methods of joint and state if the members are in tension or compression. **(20)**

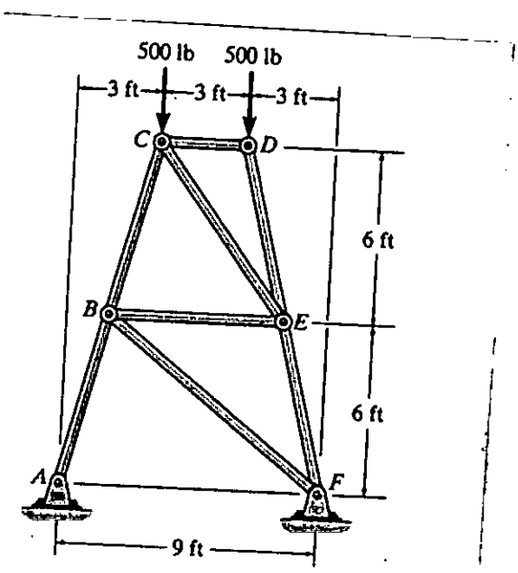

Figure 10 for question 6(a)

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Contd... Q. No. 6

(b) A dam is subjected to 3 forces: 50 kN force on the upstream vertical face AB, 40 kN force on the downstream inclined face, and its weight of 140 kN as shown in Figure 11. Determine the single equivalent force and locate its point of intersection with the base AD, assuming all the forces lie in the same plane. **(10)**

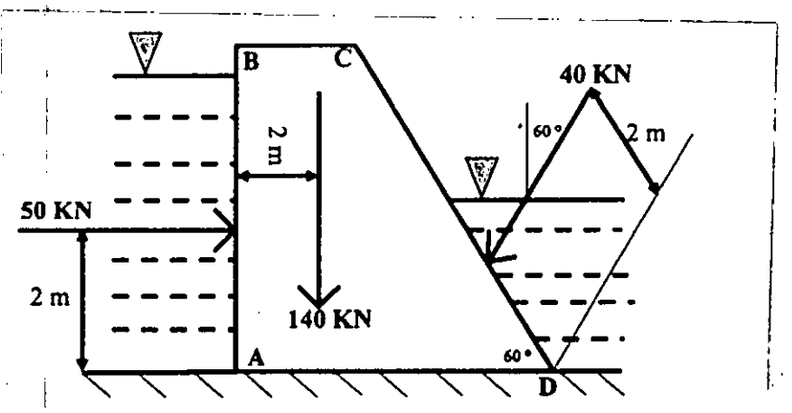

Figure 11 for question 6(b)

(c) What is the height h of the step so that the force P will roll the cylinder of weight 25 kg over the step without impending slippage at the point of contact A? Take the coefficient of friction to be equal to 0.3. **(5)**

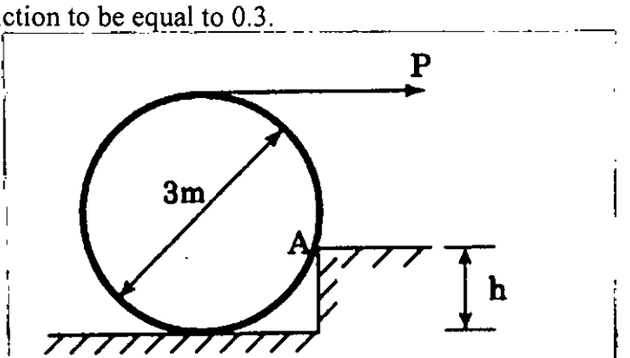

Figure 12 for question 6(c)

7. (a) Determine the forces in the members identified by "X" (member CF, CG, GE) of the truss shown by the method of sections. **(15)**

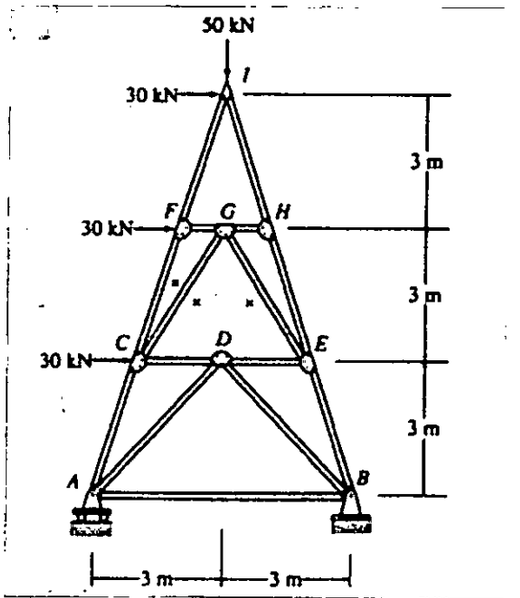

Figure 13 for question 7(a)

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Contd... Q. No. 7

(b) Determine the resultant force at pins A, B, and C on the three-member frame. **(15)**

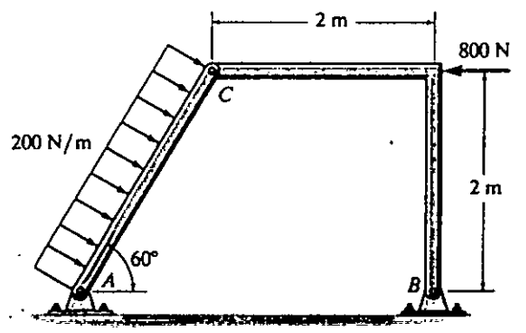

Figure 14 for question 7(b)

(c) Determine the largest angle θ that will cause the wedge to be self-locking regardless of the magnitude of horizontal force P applied to the blocks. The coefficient of static friction between the wedge and the blocks is = 0.3. Neglect the weight of the wedge. **(5)**

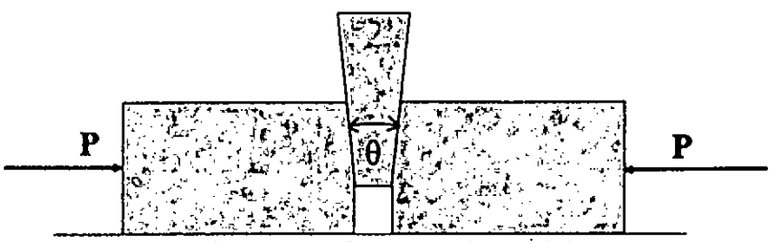

Figure 15 for question 7(c)

8. (a) Determine the maximum and the minimum values of weight W which may be applied without causing the 50-lb block to slip. The coefficient of static friction between the block and the plane is 0.2 and between the rope and the drum D is 0.3. Assume no friction between the weight and the plane. **(10)**

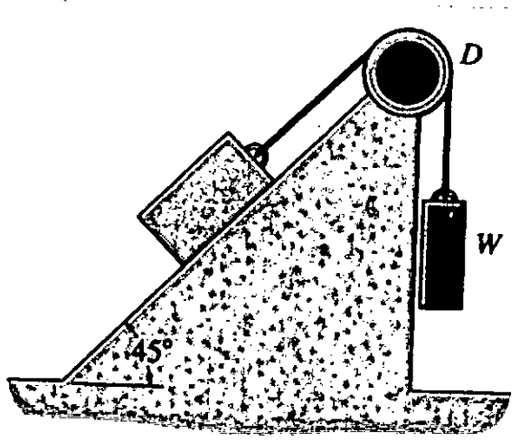

Figure 16 for question 8(a)

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Contd... Q. No. 8

(b) The spheres A, B, and C Weighing 200N, 400N, and 200N respectively, and having radii of 400 mm, 600 mm, and 400 mm respectively are placed in a trench as shown in the figure. Treating all contact surfaces as smooth, determine the reactions developed. **(10)**

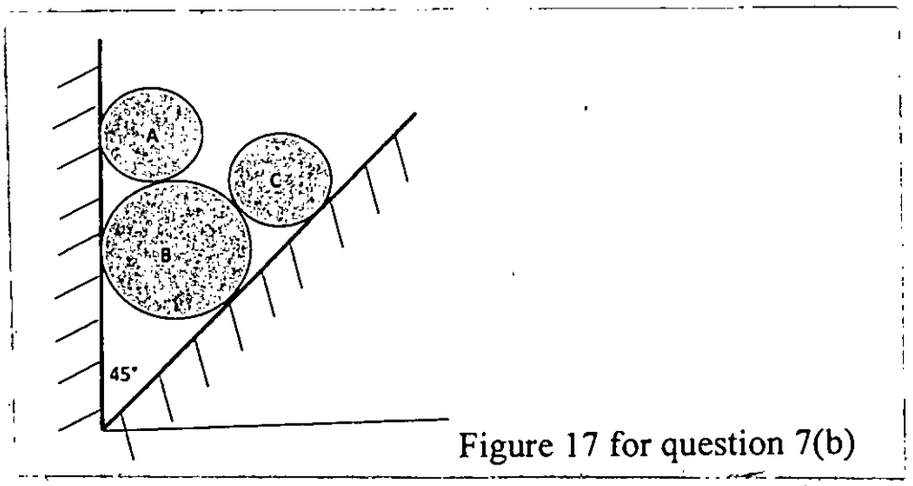

Figure 17 for question 7(b)

(c) Determine the tension in each segment of the cable as shown in the figure. **(15)**

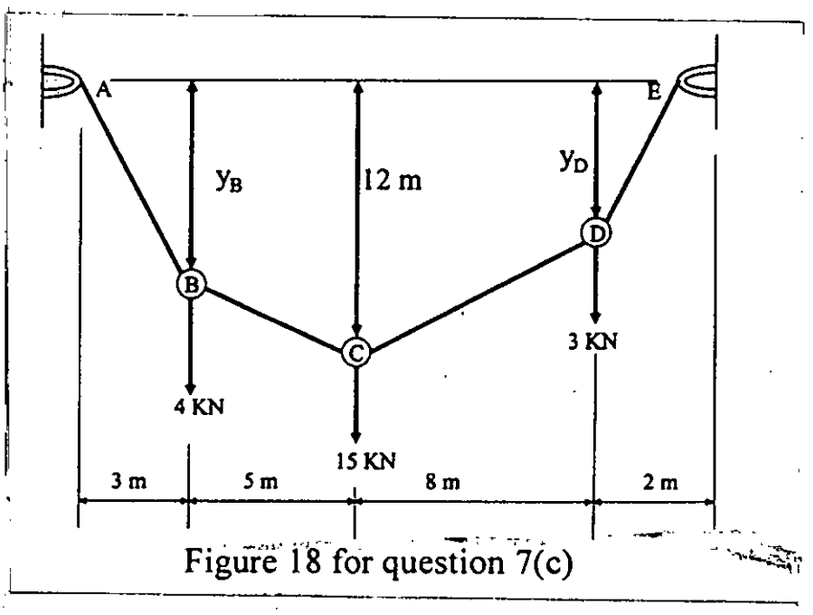

Figure 18 for question 7(c)

L-1/T-1/WRE Date: ~~18/04/2024~~ 25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **PHY 107** (Physical Optics, Waves & Oscillations and Heat & Thermodynamics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) What do you understand by coherent light? State the difference between optical and geometrical paths. **(8)**

   (b) Light from an extended source falls obliquely on a thin film of an optical medium. Find an expression for the effective path differences between a part of a ray reflected externally at the first surface and the part which suffers one reflection internally at the other surface. **(20)**

   (c) A soap film of thickness 5×10^{-5} cm is viewed at an incident angle of 35° to the normal. Find the wavelength of light in the visible spectrum which will be absent from the reflected light. Refractive index of the film is 1.33. **(8)**

2. (a) What is diffraction of light? Draw the diffraction patterns due to a single slit and a grating and compare them. **(8)**

   (b) Derive an expression for the intensity at a screen due to Fraunhofer type of diffraction by two nearby parallel slits illuminated by monochromatic light. Draw a general pattern of this intensity. **(20)**

   (c) What is the highest order spectrum, which is seen with monochromatic light of wavelength 600 nm by means of a diffraction grating with 5000 lines/cm. **(7)**

3. (a) What do you understand by optical activity of a substance? Write down the names of three optically active substances. Define specific rotation. **(8)**

   (b) Construct an outfit of the Laurent's half-shade polarimeter and discuss the working principle of it. **(20)**

   (c) A 20 cm long tube containing sugar solution rotates the plane of polarization of light by 11°. If the specific rotation of sugar solution is 66°, calculate the concentration of the solution. **(7)**

4. (a) What are reverberation and reverberation time? Mention the factors that affect the reverberation time of an auditorium. **(7)**

   (b) Explain analytically the concept of phase velocity and group velocity. Find the relation between group velocity and phase velocity. When does the group velocity become equal to the phase velocity? **(18)**

   (c) The dispersion equation of a waveguide, which relates the wavenumber k to the frequency ω, is $k=\frac{1}{c}\sqrt{\omega^2+\omega_0^2}$, where the speed of light $c = 3 \times 10^8$ *m/s*, and ω_0 is constant. If the group velocity is 4×10^8 *m/s*, then find the phase velocity. **(10)**

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SECTION – B

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

Symbols have their usual meanings.

5. (a) Describe differences among free oscillations, damped oscillations and forced oscillations. **(8)**

(b) If the mass of a spring m is not negligible but small compared to the load M of the object suspended from it, then using the concept of conservation of total mechanical energy show that the time period of the oscillation is $T = 2\pi\sqrt{\frac{M+\frac{m}{3}}{k}}$. From the above equation, discuss the impact of spring's mass in the oscillation. **(17)**

(c) In a vertical spring-mass system, the period of the oscillation is 0.22 s when the load is 0.45 kg, and period becomes 0.32 s when an additional load of 0.35 kg is added. Calculate the mass of the spring and the force constant of the spring. **(10)**

6. (a) What are Lissajous' figures? On what factors do they depend? Describe how these figures are useful in the laboratory. **(8)**

(b) Two oscillating bodies of masses m_1 and m_2 are connected by a spring on a horizontal frictionless surface. Show that their relative motion can be represented by the oscillation of a single body having reduced mass μ. **(17)**

(c) Two masses, 1.8 kg and 2.0 kg, are connected by a spring. Find the oscillation frequency of the two-body system. Given that the extension of the spring is 1.8 cm for the applied force of 2.5 N. **(10)**

7. (a) State Carnot's theorem and the second law of thermodynamics. **(8)**

(b) Two reversible engines, A and B, are operating between the same two temperature limits, T_1 (higher) and T_2 (lower). Prove that their efficiencies are equal. **(17)**

(c) A Carnot engine has an efficiency of 50%. On increasing the temperature of the sink reservoir by 100°C, the efficiency drops to 40%. By what amount should the source reservoir temperature be increased to restore the original efficiency? **(10)**

8. (a) State the Law of equipartition of energy and the degree of freedom. **(8)**

(b) Explain, with the help of Callender and Griffith's bridge, how a platinum resistance thermometer works for measuring unknown temperature. **(17)**

(c) To calculate the rotational kinetic energy of a triatomic linear gas molecule (CO_2) and a nonlinear gas molecule (H_2O) at 27°C. Given R=8.314 J/mole-K and N=6.023×10^{23} mol^{-1}. **(10)**

L-1/T-1/WRE Date: ~~30/03/2024~~ 19/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **MATH 131** (Differential Calculus and Integral Calculus)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Define the continuity and differentiability of a function. Explain the relationship between them. **(15)**

   (b) Find values of the constants k and m, if possible, that will make the function f continuous everywhere. **(20)**

$$f(x)=\begin{cases} x^2+5, & x>2 \\ m(x+1)+k, & -1<x\le 2 \\ 2x^3+x+7, & x\le -1 \end{cases}$$

   Hence sketch the graph of $f(x)$.

2. (a) State Rolle's Theorem. Show that Rolle's Theorem is not valid for the function $f(x)=|x|$ as $f'(x)$ does not exist for a value of x in $[-1,+1]$. **(10)**

   (b) Find $\lim_{x\to\pi^-}(x-\pi)\tan\frac{1}{2}x$. **(10)**

   (c) If $x=\sin\left(\frac{1}{m}\ln y\right)$, then find $(y_n)_0$. **(15)**

3. (a) Explain the difference between a relative maximum and an absolute maximum. **(10)**

   (b) An open box is to be made from a 16-inch by 30-inch piece of cardboard by cutting out squares of equal size from the four corners and bending up by sides. What size should the squares be to obtain a box with the largest volume? (Draw the graph). **(10)**

   (c) Define Total Derivative of a function of three variables. **(15)**

   If $F(v^2-x^2, v^2-y^2, v^2-z^2)=0$, where $v=f(x,y,z)$ then find the value of

$$\frac{v}{x}\frac{\partial v}{\partial x}+\frac{v}{y}\frac{\partial v}{\partial y}+\frac{v}{z}\frac{\partial v}{\partial z}.$$

4. (a) If $x\cos\alpha+y\sin\alpha=p$ touches the curve $\left(\frac{x}{a}\right)^m+\left(\frac{y}{b}\right)^m=1$, find the value of **(15)**

$$(a\cos\alpha)^{\frac{m}{m-1}}+(b\sin\alpha)^{\frac{m}{m-1}}.$$

   (b) Find the equation of the circle of curvature of the curve $y=\sin x$ at the point $\left(\frac{\pi}{2}, 1\right)$. **(10)**

   (c) Find the angle of intersection of the curves **(10)**

$$r=\sin\theta+\cos\theta \text{ and } r=2\sin\theta.$$

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MATH 131/WRE

SECTION – B

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

5. (a) Define antidifferentiation. **(5)**

(b) Work out the following integrals:

(i) $\int \frac{x^3+x^2+x+1}{\sqrt{x^2+2x+3}}\,dx$ **(10)**

(ii) $\int \frac{x^2}{(x\sin x+\cos x)^2}\,dx$ **(10)**

(c) Obtain the reduction formula for $\int \sin^n x\,dx$ and hence evaluate $\int_0^{\pi/2} \sin^6 x\,dx$. **(10)**

6. (a) Evaluate $\lim_{n\to\infty}\left[\left(1+\frac{1}{n}\right)\left(1+\frac{2}{n}\right)^{1/2}\left(1+\frac{3}{n}\right)^{1/3}\cdots\left(1+\frac{n}{n}\right)^{1/n}\right]$. **(12)**

(b) Evaluate $\int_0^{\frac{\pi}{2}} \log(\cos x)dx$. **(11)**

(c) For what values of p does the integral $\int_1^{\infty}\frac{dx}{x^p}$ converge? **(12)**

7. (a) Define Beta and Gamma functions. **(5)**

(b) Prove that Beta function is a symmetric function. Hence evaluate $\int_0^1 x^3(1-x)^{\frac{4}{3}}dx$. **(10)**

(c) Prove that $\int_0^1 \frac{dx}{\sqrt{1-x^n}} = \frac{\sqrt{\pi}}{n}\frac{\Gamma\left(\frac{1}{n}\right)}{\Gamma\left(\frac{1}{n}+\frac{1}{2}\right)}$. **(10)**

(d) Evaluate $\int_0^3\int_0^{\sqrt{9-z^2}}\int_0^x xydydxdz$. **(10)**

8. (a) Find the area of the region enclosed by the curves $y^2 = 4x$ and $y = 2x-4$. **(12)**

(b) Use cylindrical shells to find the volume of the solid generated when the region enclosed by $y = 2x-1$, $y = -2x+3$, $x = 2$ is revolved about the y-axis. **(13)**

(c) Find the area of the surface that is generated by revolving the portion of the curve $y = x^3$ between $x = 0$ and $x = 1$ about the x-axis. **(10)**
