The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

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Study Programme	Bachelor of Technology Honours in Engineering
Name of the Examination	Final Examination
Course Code and Title	**DMX3302 Engineering Mechanics**
Academic Year	2021/2022
Date	06th January 2023 (Monday)
Time	1330 – 1630 hrs
Duration	**03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Three (3)** parts in **Six (6)** pages.
3. Answer All questions in **Part A** and **Three (3)** questions from **Part B1 and Part B2, selecting at least ONE question from Part B1 and Part B2.**
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting.

PART - A (ANSWER ALL QUESTIONS)

(1) A particle is moving with a velocity of $\mathbf{v_o}$ when displacement, $\mathbf{s = 0}$ and time, $\mathbf{t = 0}$. This particle subjected to a deceleration of $\mathbf{a = - kv^3}$, where **k** is a constant and v is the instant velocity. (5 marks)
Determine the velocity and the position of the particle as functions of time.

(2) The box of negligible size is sliding down along a curved path (Fig. A2) defined by the parabola $\boldsymbol{y = 0.4x^2}$. When it is at point **A** ($\boldsymbol{x_A = 2}$ m, $\boldsymbol{y_A = 1.6}$ m), the speed of the box is $\boldsymbol{v = 8}$ m/s and the increase in speed is $\boldsymbol{dv/dt = 4}$ m/s^2. (5 marks)
Determine the radius of curvature and the magnitude of the acceleration of the box at this instant.

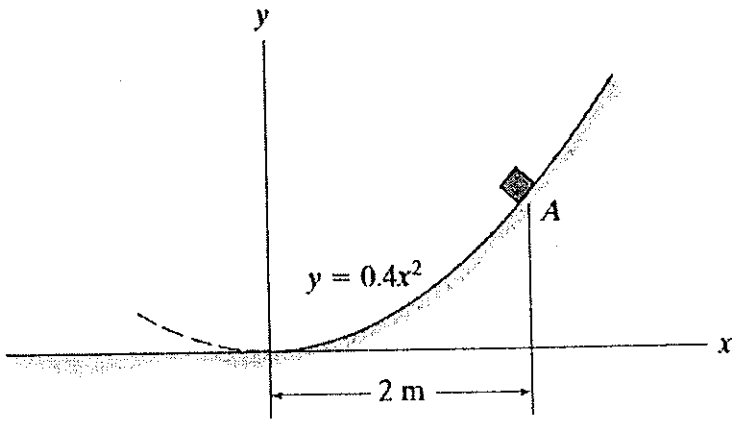


Fig. A2

(3) A man walks at $v_m = 5$ km/h in the direction of a $v_w = 20$ km/h wind. If raindrops fall vertically at $v_{r/w} = 7$ km/h in still air (relative to wind), determine direction in which the drops appear to fall with respect to the man. (5 marks)

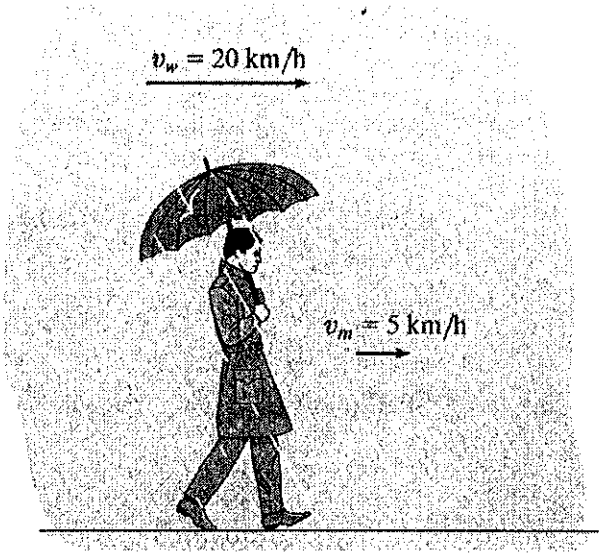


Fig. A3

(4) The coefficient of static friction between the **200** kg crate and the flat bed of the truck is $\mu_s = 0.3$. Determine the shortest time for the truck to reach a speed of **60** km/h, starting from rest with constant acceleration, so that the crate does not slip. (Fig. A4) (5 marks)

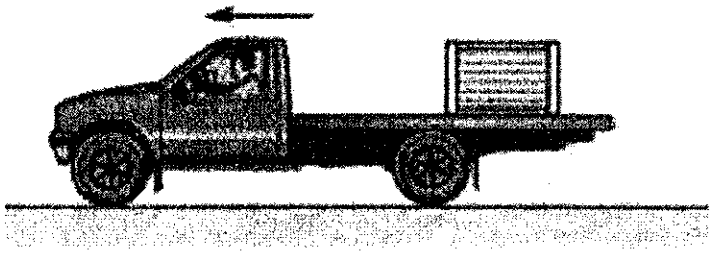


Fig. A4

(5) The **8** kg block **B** is moving with an initial speed of **5** m/s and distance of **2** m away from the spring **A** (Fig. A5). If the coefficient of kinetic friction between the block and plane is $\mu_k = 0.25$, determine the compression in the spring when the block momentarily stops. Take spring constant as **200** N/m. (5 marks)

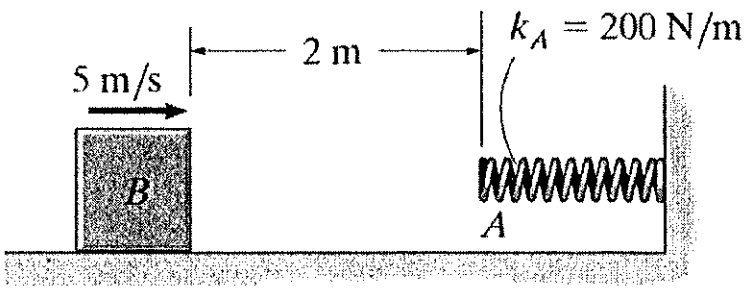


Fig. A5

Hint : *Use principle of work and energy*

(6) The **20** g bullet is traveling at **400** m/s when it becomes embedded in the 2 kg stationary block as shown in Fig. A6. Determine the time, the block will slide, before it stops. The coefficient of kinetic friction between the block and the plane is $\mu_k = 0.2$. (5 marks)

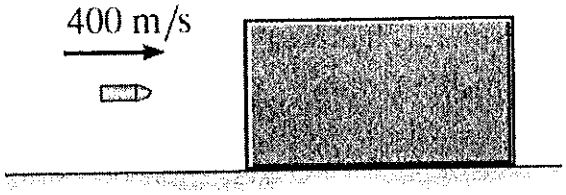


Fig. A6

(7) A force of **P** = **300** N is applied to the **60** kg cart as shown in Fig. A7. Determine the reactions at both the wheels at **A** and both the wheels at **B**. What is the acceleration of the cart? The mass center of the cart is at **G**. (5 marks)

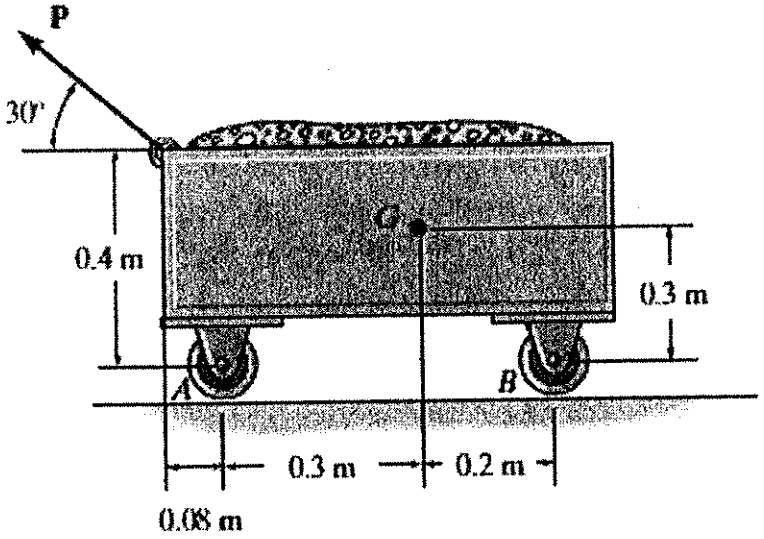


Fig. A7

(8) The two blocks A and B have a mass m_A and m_B, respectively, where $m_B > m_A$. If the pulley can be treated as a disk of mass **M** and radius **r**, determine the acceleration of block A. Neglect the mass of the cord and any slipping on the pulley. (Fig. A8) (5 marks)

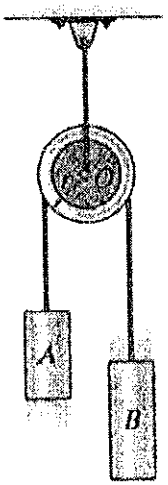


Fig. A8

PART – B (ANSWER THREE QUESTIONS SELECTING AT LEAST ONE QUESTION FROM PART B1 AND PART B2)

PART – B1 (ANSWER AT LEAST ONE QUESTION)

QUESTION 01 (20 marks)

(a) State the equations of equilibrium, for a particle which is in equilibrium under several three-dimensional forces. (3 marks)

(17 marks)

(b) Determine the tension developed in cables **AB** and **AC** and the force developed along strut **AD** for equilibrium of the **40** kg crate as shown in Fig B1.

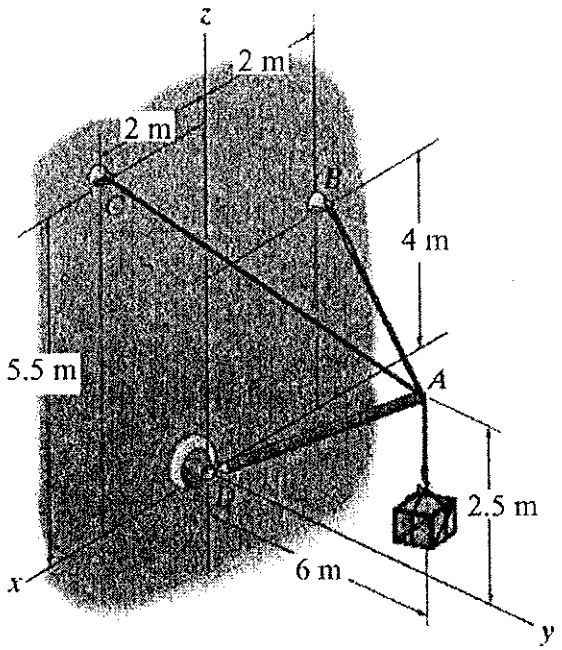


Fig. B1

QUESTION 02 (20 marks)

A spring with spring constant **k** and a block with mass **m** is attached to a support as shown inFig. B2, which moves harmonically $\delta = \delta_0 \sin(\omega_0 t)$. The displacement **x** of the block is measured from the static equilibrium position.

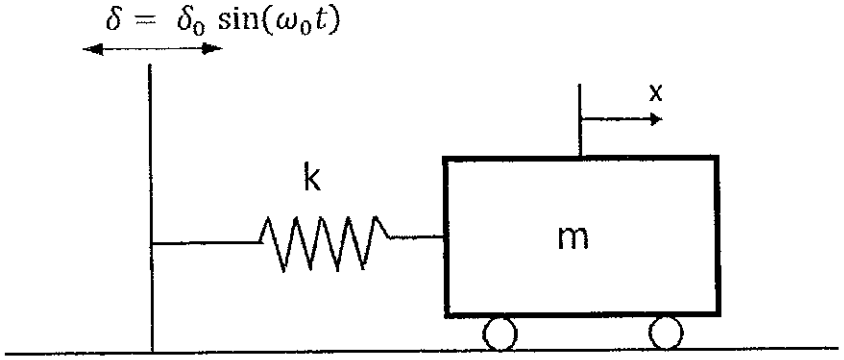


Fig. B2

(a) Find the governing equation of the block's motion. (Use standard notations) (5 marks)

(b) General form of the solution can be written as $x = x_c + x_p$. For this system x_p can be written as $x_p = C\sin(\omega_0 t)$. Find the value of constant C. (3 marks)

(c) Write the general form of the remaining part of the solution x_c with constants A and B. (2 marks)

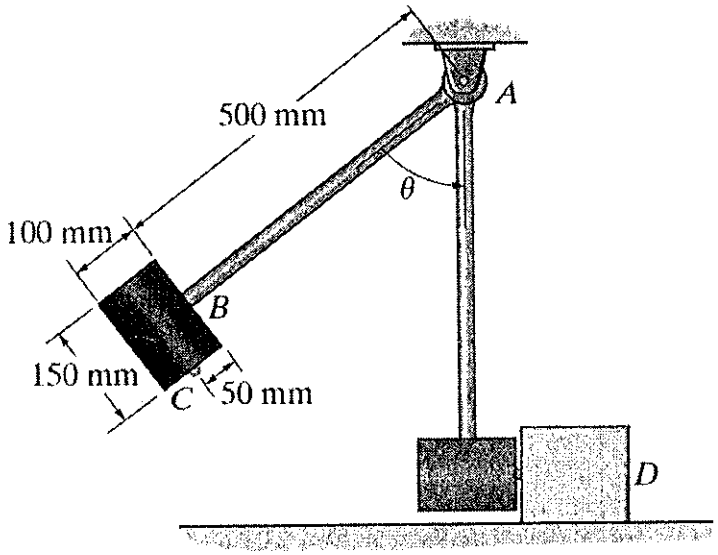
(d) Write down the complete solution for the motion of the block and state how to compute the constants A and B. (2 marks)

(e) If **m = 5** kg, **k = 300** N/m and $\delta = 7/300 \sin(10t)$ where t is in seconds, determine the equation of the blocks motion when it is pulled 100 mm from the equilibrium position and released from rest at t =0. (8 marks)

QUESTION 03 (20 marks)

(a) Explain the coefficient of restitution. What is the difference between an elastic impact and a plastic impact? (3 marks)

(b) The hammer consists of a 10 kg solid cylinder C and 6 kg uniform slender rod AB (Fig. B3). If the hammer is released from rest when $\theta = 90°$ and strikes the 30 kg block D when $\theta = 0°$, determine the velocity of block D and the angular velocity of the hammer immediately after the impact. The coefficient of restitution (e) between the hammer and the block is e = 0.6. (17 marks)



The mass moment of inertia of rod AB above mass center $I_{ABG} = \frac{1}{12}ml^2$

The mass moment of inertia of cylinder above mass center $I_{GC} = \frac{1}{12}(3r^2 + h^2)$

Fig. B3

PART – B2 (ANSWER AT LEAST ONE QUESTION)

QUESTION 04 (20 marks)

(a) Briefly explain about the (i) Centroid, (ii) First Moment and (iii) Second Moment of area. (3 marks)

(b) Determine the location $(\bar{x}, \bar{y})$ to the centroid C of the angle's cross-sectional area (Fig. B4). Determine the orientation of the principal axes of inertia through the centroid of the section and determine the corresponding maximum and minimum moments of inertia. (18 marks)

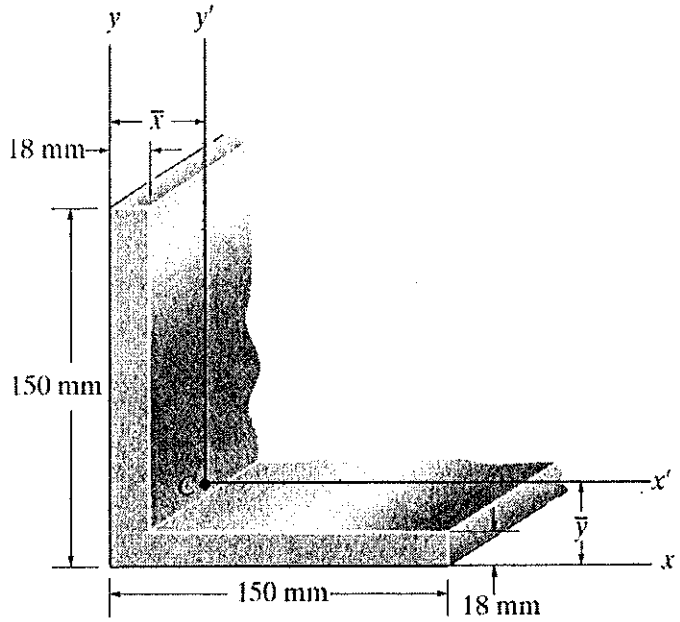


Fig B4

QUESTION 05 (20 marks)

(a) Mark the reaction forces at the supports if a beam is supported by (i) a roller support (ii) a pin joint and (iii) a fixed support.(consider the supports are for two dimensional systems). (4 marks)

(b) Draw the shear and moment diagrams for the beam shown in Fig B5. What is the location of maximum bending moment. (13 mark)

(c) Find the value of shear force at 1.9 m and at 2.1 m. What is the reason for the sudden change in shear force value? (3 marks)

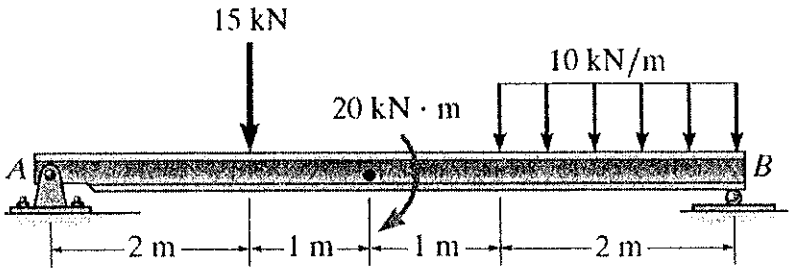


Fig. B5