UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: March 2026

Module Number: ME2201 **Module Name: Engineering Mechanics (C23)**

[**Three** Hours]

[Answer **all questions**, each question carries **twelve marks**]

Provide neat sketches and state any reasonable assumptions made. Make sure to use standard notations and SI units where appropriate. Take $g = 9.81\ m/s^2$.

Q1. a) Differentiate and identify the following with supportive figures.

(i) Collinear forces

(ii) Concurrent forces

[2.0 Marks]

b) What are the conditions for a rigid body to be at equilibrium?

[1.0 Mark]

c) A uniform rod is in equilibrium under the influence of a force and a couple moment as depicted in **Figure Q1(c)**. The rod is supported at point A by a smooth wall and at points B and C by rollers, either at the top or bottom.

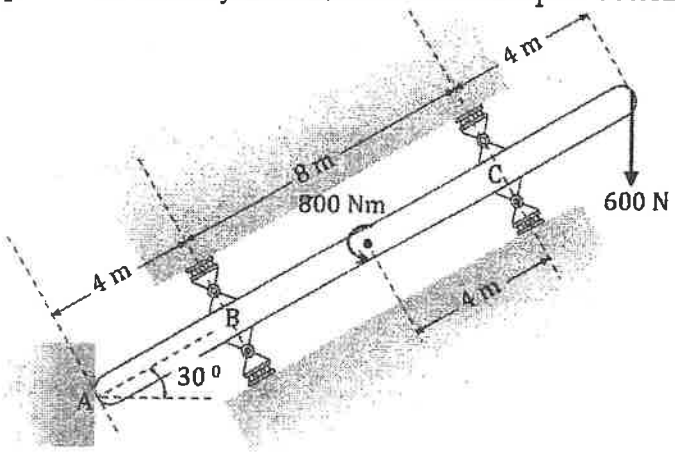

Figure Q1(c)

(i) Draw the free-body diagram.

(ii) Write the equations of equilibrium.

(iii) Determine the reactions at the supports.

[9.0 Marks]

Q2. a) Define average acceleration and instantaneous acceleration.

[2.0 Marks]

b) Define Kinematics and Kinetics in engineering mechanics. Explain the differences between these two concepts.

[2.0 Marks]

c) A man standing at point A pulls a rope in order to hoist a load M, as shown in the **Figure Q2(c)**. The rope passes over a small pulley at point D located at the top of a vertical wall. The total length of the rope is 30 m. The man walks horizontally away from the wall with a constant velocity of $V_A = 1$ m/s. As the man moves, the load rises vertically along the wall, and the man pulls the rope at ground level. Determine the followings by neglecting the height of the man.

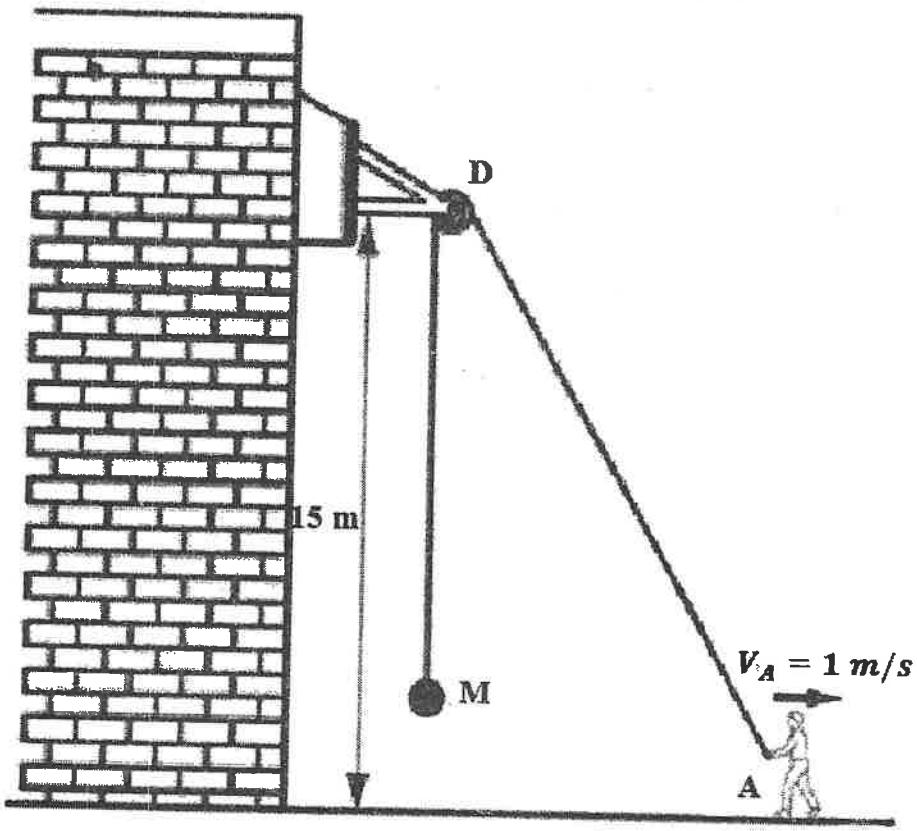

Figure Q2(c)

(i) The velocity of the load M when it reaches a height of 10 m.

[3.0 Marks]

(ii) The acceleration of the load M at that instant.

[3.0 Marks]

(iii) The Load M has a mass of 20 kg. Determine the tension in the rope at the instant when the load reaches a height of 10 m, assuming the pulley is frictionless and the rope has negligible mass.

[2.0 Marks]

Q3. a) Briefly explain the differences between conservative and non-conservative forces, with an example.

[2.0 Marks]

b) The two blocks A and B have mass $m_A = 30$ kg and $m_B = 5$ kg as shown in **Figure Q3(b)**. If the kinetic fiction coefficient between the inclined plane and the block A is $\mu_k = 0.2$. Determine the speed of A after it moves 1 m down the plane starting from rest. Neglect the mass of the cord and pulleys.

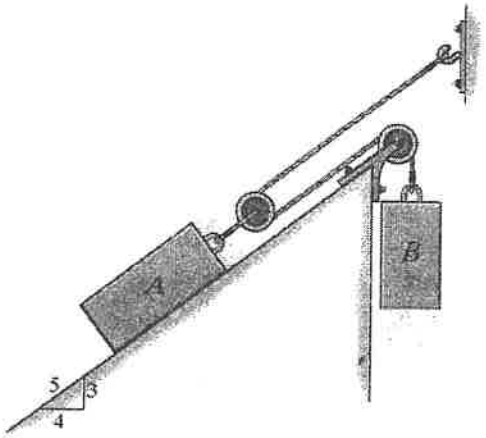

Figure Q3(b)

[5.0 Marks]

c) A 10 kg block rests on a rough surface with a kinetic friction coefficient of $\mu_k = 0.2$. A force $F = (300 + s^2)\ N$, where "s" is measured in meters, acts on the block in the direction shown in **Figure Q3(c)**. The spring is initially unstretched ($s = 0$), and the block starts from rest. Determine the power developed by the force at the instant the block has moved $s = 0.5$ m. The spring constant is $k = 0.3$ N/mm.

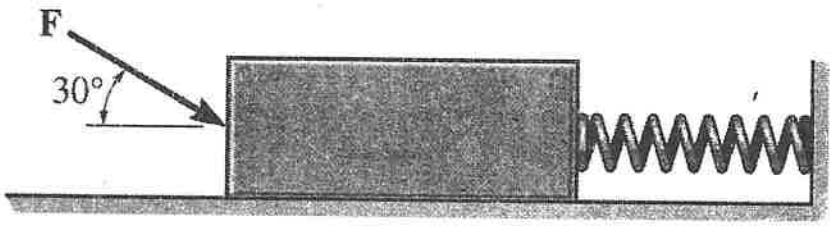

Figure Q3(c)

[5.0 Marks]

Q4. a) (i) Derive the principle of linear impulse and momentum for a system of particles, starting from the equation of motion for a particle of mass "m".

(ii) Hence, derive the principle of angular impulse and momentum for system of particles.

[4.0 Marks]

b) A 4 kg disk (A) is attached to the end of a light arm BC of negligible mass as shown in **Figure Q4(b)**. A time-dependent torque $M = 5e^{0.5\,t}\ Nm$ is applied to

the arm at point C, where "t" is measured in seconds. Determine the angular velocity of arm BC at $t = 2$ s, starting from rest, consider the following cases:

(i) The disk is mounted in a smooth bearing at B, allowing curvilinear translation of the disk relative to the arm.

(ii) The disk is rigidly fixed to the shaft BC.

(iii) The disk is given an initial, freely spinning angular velocity of $\omega_D = 80$ rad/s prior to the application of the torque.

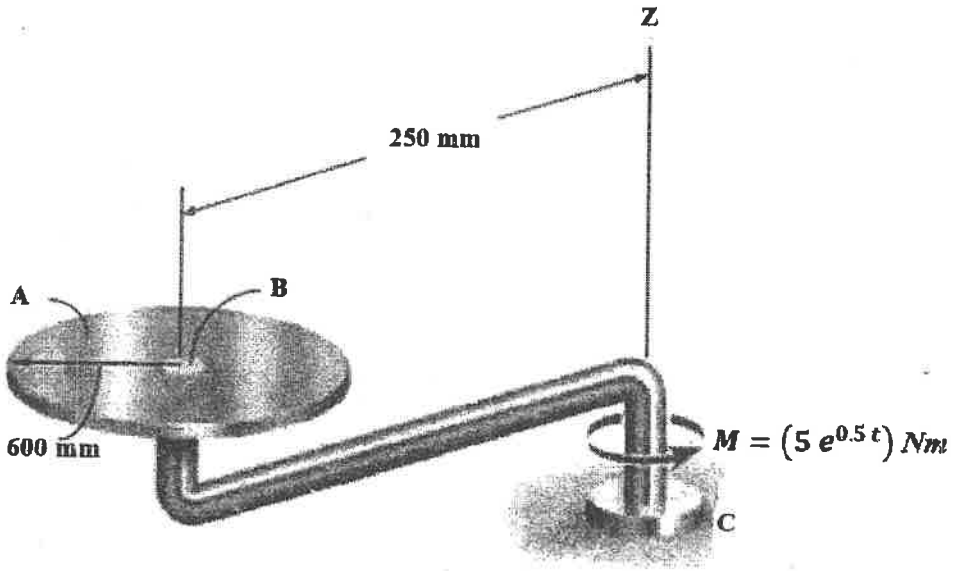

Figure Q4(b)

[4.0 Marks]

c) A rocket sled of mass 4000 kg moves along a straight horizontal track while being subjected to a time varying thrust force of $T = 4\, t^{1/2}\ kN$ as shown in the provided force–time graph (**Figure Q4(c)**). Assuming negligible friction and air resistance, determine the maximum velocity and the distance the sled travels when $t = 35$ s.

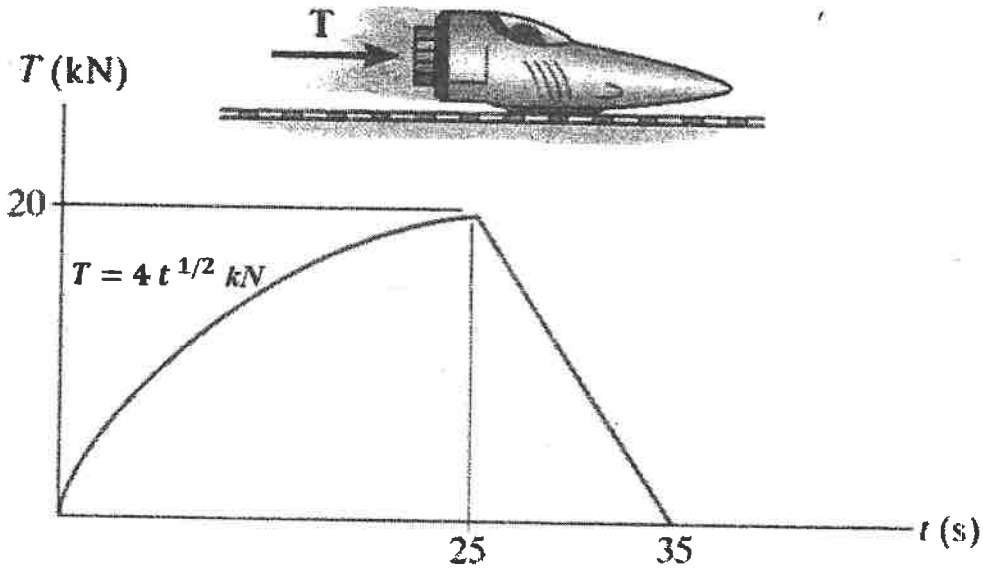

Figure Q4(c)

[4.0 Marks]

Q5. a) A four-bar linkage consists of four rigid links connected by pin joints to form a closed chain. Explain the concept of kinematic inversion in a four-bar linkage mechanism, and describe how different mechanisms can be obtained by fixing different links.

[2.0 Marks]

b) State and explain Grashof's theorem for a four-bar linkage. Clearly define the terms involved.

[1.0 Mark]

c) A four-bar linkage has link lengths of $AB = 30$ mm, $BC = 60$ mm, $CD = 90$ mm, and $AD = 70$ mm.

(i) Determine whether the mechanism satisfies Grashof's condition.

(ii) Identify all the inversion of given four bar linkage mechanism and state which link(s) can have complete rotation, with suitable sketches.

[3.0 Marks]

d) (i) What is meant by the Degree of Freedom (DOF) of a mechanism?

(ii) Draw skeleton diagrams and determine the DOF of mechanisms given in **Figure Q5 (a)**, and **Figure Q5 (b)**.

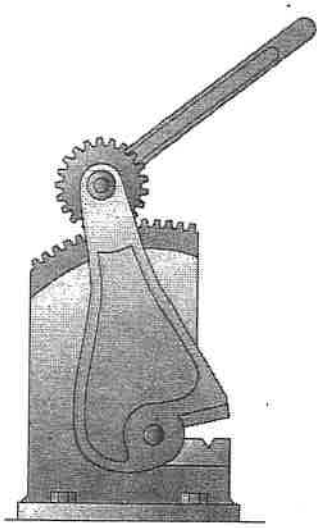

Figure Q5(a): Shear press mechanism

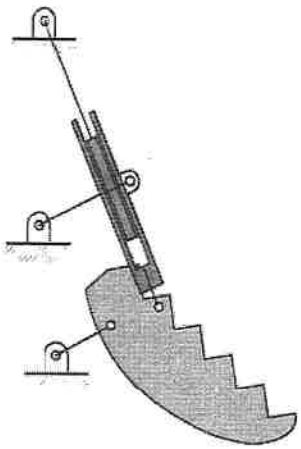

Figure Q5(b): Aircraft Door

[6.0 Marks]