MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 208: ENGINEERING MECHANICS II

DATE: 14/12/2020 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS) (COMPULSORY)

a) At a certain instant, a body of mass 10 kg falling freely under the force of gravity was found to be falling at the rate of 20 m/s. Determine from that instant, the force required to stop the body:

i. in 2 seconds (3 marks)

ii. in 2 metres (3 marks)

b) The acceleration of a particle varies with time **t** and is given by a = 2 - 3t. It is observed that the velocity of the particle is 20 m/s when time is 5 sec and also that the particle is 85 m from the origin when time is 10 sec. Determine:

i. the acceleration, velocity and distance when t = 0 (6 marks)

ii. the time when velocity is zero (3 marks)

c) A 50 kg block rests on a horizontal plane for which the coefficient of friction is 0.3. If the block is acted upon by a 400 N force acting at 30^0 from the horizontal as shown in Fig Q1c. Determine:

i. the velocity of the block after 5 sec (4 marks)

Fig Q1c.

ii. the horizontal distance covered by the block within that time (2 marks)

d) i Distinguish between work and energy. (2 marks)

ii A wagon of mass 50 tonnes starts from rest at the top of a slope inclined at 1 in 100 and travels 30 m down the slope before being stopped by a bumber spring. If in its motion, the wagon experiences a rolling resistance of 50 N/tonne and the bumper spring has a compression of 1mm per 20 kN force. Determine:

I. the velocity with which the wagon strikes the bumber spring. (4 marks)

II. the amount by which the spring will be compressed (3 marks)

QUESTION TWO (20 MARKS)

a) i State Newton's law of gravitation (2 marks)

ii Describe with suitable sketches Kepler's laws of planetary motion (8 marks)

b) An astronaut releases a navigation ball of mass 7.2 kg into a circular orbit about the earth at an altitude of 350 km. Given that the radius of the earth = 6370 km, Gravitational constant = 6.67×10^{-11} m^3/kgs^2, Mass of the earth = 5.98×10^{24} kg, Mass of sun = 1.99×10^{30} kg; determine;

i. the mechanical energy of the ball in its orbit: (3 marks)

ii. the mechanical energy of the ball at the point of launch (2 marks)

c) Determine the constant speed of a satellite so that it circles the earth with an orbit of radius $15x10^6$ m. Take the mass of the earth as $5.98\ x10^{24}$kg (5 marks)

QUESTION THREE (20 MARKS)

a) The angular displacement of a particle moving along a circular path of radius 20 m is given by the equation: $\Theta=18t+3t^2-2t^3$; where Θ is the angular displacement after time t. Find:

i. the angular acceleration at the start (2 marks)

ii. the time when the particle attains its maximum angular velocity (2 marks)

iii. the maximum angular velocity (2 marks)

iv. the linear velocity corresponding to(iii) above (2 marks)

b) A passenger of mass 82 kg stands on a scale inside an elevator cabin. Determine

i. the scale reading when the cab is accelerating upwards at 3.20 m/s^2 (2 marks)

ii. the acceleration when the scale reading is 477 N. (3 marks)

c) A certain force gives an object of mass $\mathbf{m_1}$ an acceleration of 15.0 m/s^2 and another object of mass $\mathbf{m_2}$ an acceleration of 6.0 m/s^2. Determine the acceleration which this force would impart to an object of mass:

i. $(\mathbf{m_1 + m_2})$ (4 marks)

ii. $(\mathbf{m_2 - m_1})$ (3 marks)

QUESTION FOUR (20 MARKS)

a) i) State D'Alemberts principle (2 marks)

ii) Two blocks of mass 80 kg and 20 kg respectively are connected by a cable and move along a rough horizontal plane under the action of a force of 400 N applied to the first body as shown in Figure Q4(a). If μ = 0.3 between the contacting surfaces, determine the acceleration of the two blocks and the tension in the connecting cable (9 marks)

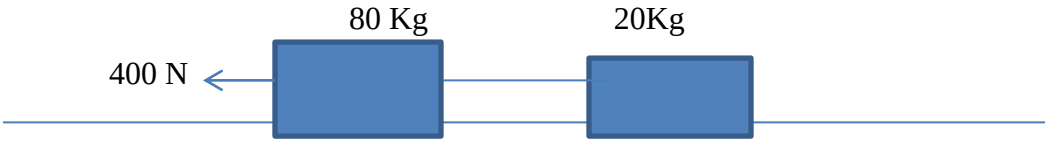

Fig Q4(a)

b) A solid cylindrical pulley of 2 m diameter and mass 800kg with 0.8m radius of gyration is rotated by an electric motor which exerts a torque of 60 kN-m. If a body of mass 3 tonnes is to be lifted by a cable wrapped around the pulley, Determine:

i. the acceleration of the body (6 marks)

ii. the tension in the rope (3 marks)

QUESTION FIVE (20 MARKS)

a) Derive from first principles the equation for the mass moment of inertia of a solid sphere of radius **r** and material density **ρ** about an axis passing through its centre (6 marks)

b) i) State the parallel axis theorem with respect to mass moment of inertia (3 marks)

ii) The hollow plate shown in Figure Q5(b) has an outside and inside radii of 250 and 125 mm respectively. The thickness of the plate is 10 mm and the density of the plate material is 800kg/m^3. Determine the mass moment of inertia for this plate about an axis perpendicular to its surface and passing through point 'O' as shown in the figure. (5 marks)

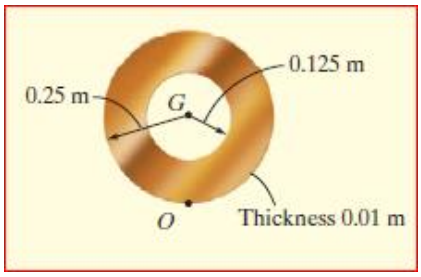

Figure Q5(b)

c) Two bodies A and B of masses 800 kg and 600 kg are attached at the ends of a flexible rope. The rope passes over a pulley of 800 mm diameter. The pulley has a mass of 100 kg with a radius of gyration of 400 mm about its axis of rotation. Neglecting friction at the spindle,

determine the torque which must be applied to the pulley in order to raise the 800 kg body with an acceleration of 1 m/s^2 (6 marks)