

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER EXAMINATIONS – MAY 2002
MECHANICAL ENGINEERING – SCH 2205
TIME – (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer **ANY FIVE** questions. All questions carry 20 marks each.

1. (a) A train starts from rest, accelerates uniformly for 500m, then it covers 1.5 km at a constant speed and is finally brought to rest under uniform retardation in 250m. If the whole journey took 5 minutes,
- (i) Draw a velocity-time sketch for the journey. Indicate the specific times for acceleration, constant velocity and retardation times (5 marks)
 - (ii) Find the acceleration and retardation. (6 marks)
- (b) A golf ball is hit with a velocity of 45ms^{-1} at an elevation of 30° along a level fairway. Find.
- (i) The greatest height reached. (3 marks)
 - (ii) Time of flight (3 marks)
 - (iii) Horizontal distance traveled (3 marks)
2. (a) A crane raises a load of 4 000kg at a constant speed of 0.6m/s. At what rate is the crane's engine working? (6 marks)
- (b) A pump discharges 3 000 litres of water per minute with a speed of 10m/s. What is the power of the pump? 1 litre of water has a mass of 1kg. (5 marks)
- (c) A drill of diameter 7mm turns at 2 500 rev/min. What is the speed of its cutting edge? (4 marks)
- (d) A particle moves under an acceleration (i-k) m/s^2 . If the particle has a mass of 2kg and is initially at rest, find its velocity and kinetic energy after 10 seconds. (5 marks)

3. (a) A mass M_1 is lying on a rough horizontal surface and M_2 is hanging freely over a smooth pulley. If the coefficient of friction is μ , find the acceleration of the system (Fig 1) when moving (10 marks)
- (b) Determine the tensions T_1 , T_2 and T in Figure 2. (10 marks)

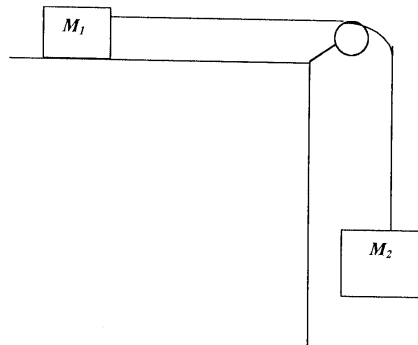


Figure 1

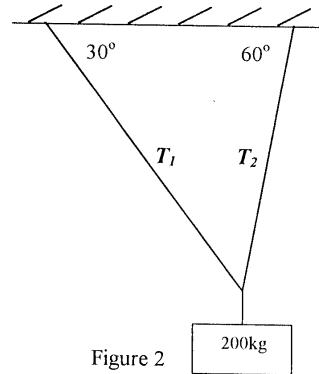


Figure 2

4. (a) A rough inclined plane is 13m long and 5m high. A body of mass M is projected with a speed of 14m/s from the bottom of the plane up a line of greatest slope and just reaches the top of the plane, using the work-energy principle determine the frictional force and hence find the coefficient of friction. (10 marks)
- (b) Find the position vector of the center of gravity of the system of particles with the following position vectors.
- 2kg at $3\mathbf{i} + 5\mathbf{j}$
 5kg at $-\mathbf{i} + 4\mathbf{j}$
 1.8kg at $-2\mathbf{i} - 4\mathbf{j}$ (10 marks)
5. (a) Define the following terms:
- (i) Toughness
 (ii) Hardness
 (iii) Shear modulus
 (iv) Secant modulus
 (v) Tangent modulus (10 marks)

5. (b) A three-point bend test is performed on a ceramic block that is 200mm long, 16cm wide and 8mm thick and is resting on two support 120mm apart. Calculate:
- The flexural strength. (5 marks)
 - The flexural modulus, assuming that no plastic deformation occurs. (5 marks)
6. (a) A non-uniform rod AB of mass 8kg and length 2m is in equilibrium in a horizontal position. It is supported by two strings, one at A and making angle of 30° with AB and the other at B making an angle of 40° with BA . Find:
- The tensions in the strings (8 marks)
 - The distance of the center of gravity from A . (4 marks)
- (b) A uniform ladder AB of mass 10kg and length $2a$ rests with A against smooth vertical wall and B on a rough horizontal floor. The ladder makes an angle β with the vertical. Find:
- The reaction between the ladder and the wall. (2 marks)
 - The normal reaction between the ladder and the floor. (2 marks)
 - The frictional force. (2 marks)
 - Least value for the coefficient of friction when $\beta = 30^\circ$. (2 marks)
7. (a) An aluminum alloy that has a plane strain fracture toughness of $54 \text{ MPa}\sqrt{\text{m}}$ fails when a stress of 350 MPa is applied. Observation of the surface indicates that the fracture is initiated at the surface. Determine the size of the flaw that initiated fracture. Assume $f = 1.1$. (8 marks)
- (b) Define the resolved shear stress. (3 marks)
- (c) An aluminium crystal slips on the (111) plane and in the [110] direction with a 4.5 MPa stress that was applied in the [111] direction. What is the critical resolved shear stress? (9 marks)

END OF QUESTION PAPER!!!