NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER TWO EXAMINATIONS – MAY 2005
MECHANICAL ENGINEERING – SCH 2205
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES
Answer ANY FIVE (5) questions.
Total Marks – 100

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1. (a) Draw displacement/time, velocity/time, and acceleration/time graphs for the following motions:

   (i) an object falling from rest under the influence of gravity.
   (ii) a box dropped from a balloon travelling vertically upwards at 40 m/ s.
   (iii) a motor car travelling from rest, accelerating at 15m/ s^2 for 10 sec, travelling for 15 seconds and then skidding to a halt after 5 seconds.
   (9 marks)

   (b) A stone thrown horizontally from the top of a tower hits the ground at a distance 18 m from the blue of the tower.

   (i) Find the speed at which the stone was thrown if the tower is 24 m high.
   (ii) Find the speed of the stone just before it hits the ground.
   (6 marks)

   (c) Forces A, B and C of magnitude 6N,9N and 12N respectively act from a point O, and are in equilibrium. Find the angle AOB. (5 marks)

2. A disc *A* shown in Figure 1 starts from rest and rotates with a constant angular acceleration of $\propto_A = 2$ rad/s^2.

   (a) How much time is needed for it to turn 10 revolutions.
   If disk *A* is in contact with disk *B* and no slipping occurs between the disks determine the angular velocity and angular acceleration of *B* just after *A* turns 10 revolutions.

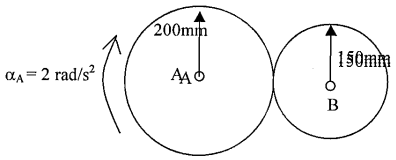

Figure 1

(5 marks)

2. (b) A compound belt and counter shaft drive is shown in Figure 2. The pulley diameters are A 72 cm, B 27 cm, C 54 cm, D 24 cm.

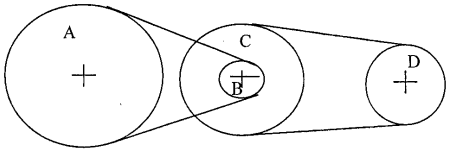

Fig 2

The power input to the pulley is 10 kw at a speed of 100 rev/min.
If the belt drive is 85% efficient, calculate:

(i) the output power (kw) at D
(ii) the speed of rotation of D
(iii) the torque exerted at D

(15 marks)

3. (a) The motion of a bead sliding down a spiral path is defined by the position vector

$\mathbf{r} = 0.5 \sin(2t)\,\mathbf{i} + 0{,}5\cos(2t)\,\mathbf{j} - 0.2t\,\mathbf{k}$.

(i) Determine the location of the bead when t= 0.75 seconds.

(iii) Find the magnitude of the bead's velocity and acceleration at the instant.
(10 marks)

(b) A particle of mass 5 kg is acted upon by a constant force of $(15\mathbf{i} + 20\mathbf{k})$ N. After 20 seconds, its velocity is $(68\mathbf{i} + 5\mathbf{j} + 74\mathbf{k})$ m/s. Find its initial velocity and the rate of work of the force at the start of motion.
(5 marks)

(c) A body of mass 2kg is acted upon by a force which at time t, is given by $(8t+4)i + 4tj$. Initially the particle is at (0,1) and moving with a velocity $3i + j$. Find the position vector of the particle at time t.
(5 marks)

4. (a) Show that when a particle is projected with a velocity V at an inclination $\propto$, the range on the horizontal plane through the point of projection is given by:

$$\frac{V \sin 2\propto}{g}$$

(8 marks)

(b) Two masses M and m are connected by a light and inextensible string over a smooth pulley. If M is bigger than m, find the acceleration of the system and the tension in the string. (6 marks)

4. (c) A particle of mass 5 kg is suspended from two strings. In equilibrium, the particle hangs with the strings at 70° and 45° to the vertical. Find the tension in the strings.

(6 marks)

5. (a) With the aid of diagrams, define the following terms and explain their importance in the strength of materials.

(i) yield stress
(ii) Young's modulus
(iii) tangent and secant modulus.

(10marks)

(b) A thermosetting polymer containing glass beads is allowed to deflect 0.5mm when a force of 500 newtons is applied. The polymer component is 2cm wide, 0.5cm thick and 10cm long. If the flexural modulus is 6.9GPa, determine the minimum distance between the supports. Will the polymer fracture if its flexural strength is 85MPa?

(10 marks)

6. (a) A body of mass 4kg is placed on a smooth plane of height 5m and length 20m. The body is connected by a light and inextensible string which passes over a smooth pulley at the top of the plane to a mass of 3kg hanging freely . If initially the 4kg mass is at rest at the bottom of the plain and the 3kg hangs just over the pulley, find:

(i) the common acceleration and tension in the string
(ii) how long it takes the hanging string to reach the ground
(iii) how far up the slope the 4kg mass goes

(10 marks)

(b) (i) Distinguish toughness from hardness. (4 marks)

(ii) Calculate the resolved shear stress on the (111)[101] slip system if a stress of 10000 Pascals is applied in the [001] direction of a FCC unit cell.

(6 marks)

7. (a) In every hour a pump draws $180m^3$ of water from a well, raises it 4m and issues it through a pipe of cross-sectional area $50cm^2$.

(i) Find the speed with which the water issues out of the pipe.
(ii) What is the power required to do this?
(iii) If the pump is 80% efficient, determine the rate at which the pump is working.

(10 marks)

7. (b) (i) What is static friction

(ii) What is kinetic friction

(iii) The crate shown in figure 3 below has a mass of 3m kg. Show that $\mu s = \tan\theta_c$ and determine the critical angle θ_c such that the crate is on the verge of moving down the plane.

(10 marks)

The coefficient of static friction is $\mu s = 0,3$

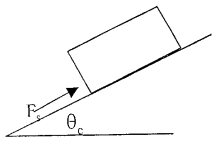

Fig 3

End of question Paper!!!