NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF APPLIED CHEMISTRY

END OF SECOND SEMESTER EXAMINATIONS – MAY 2013

MECHANICAL ENGINEERING – SCH 2205

TIME – 3 HOURS

Instructions to Candidates

This paper consists of eight (8) questions. Answer **any five (5)** questions. Each question carries 20 marks.

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1. (a) Kathy Kool buys a sports car that can accelerate at the rate of 4.90 m/s^2. She decides to test the car by racing with another speedster, Stan Speedy. Both start from rest, but experienced Stan leaves the starting line 1.00 s before Kathy. If Stan moves with a constant acceleration of 3.50 m/s^2 and Kathy maintains an acceleration of 4.90 m/s^2. Find:

(i) time at which Kathy overtakes Stan, [3]

(ii) distance she travels before she catches him, and [3]

(iii) speeds of both cars at the instant she overtakes him. [6]

(b) A rock is dropped from rest into a well. The well is not really 16 seconds deep, as illustrated in Figure 1:

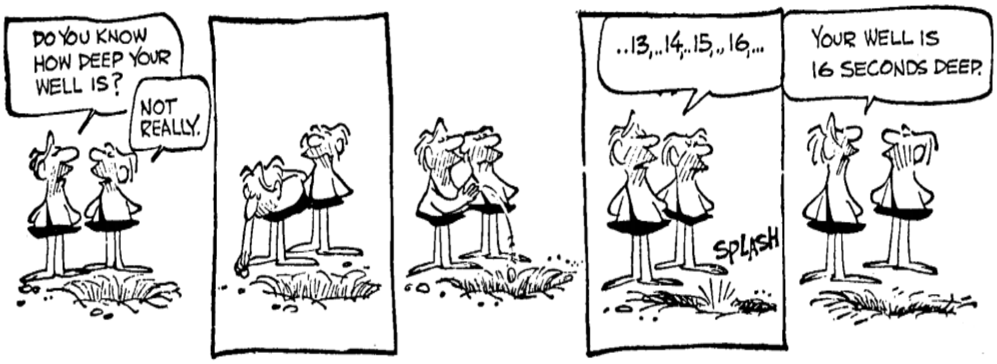

Figure 1

(i) The sound of the splash is actually heard 2.40 s after the rock is released from rest. How far below the top of the well is the surface of the water? The speed of sound in air (at the ambient temperature) is 336 m/s. [6]

(ii) If the travel time for the sound is neglected, what percentage error is introduced when the depth of the well is calculated? [2]

2. (a) A 50.0 kg woman balances on one heel of a pair of high-heeled shoes. If the heel is circular and has a radius of 0.500 cm, what pressure does she exert on the floor? [2]

(b) Mercury is poured into a U-tube as in the Figure 2(a).

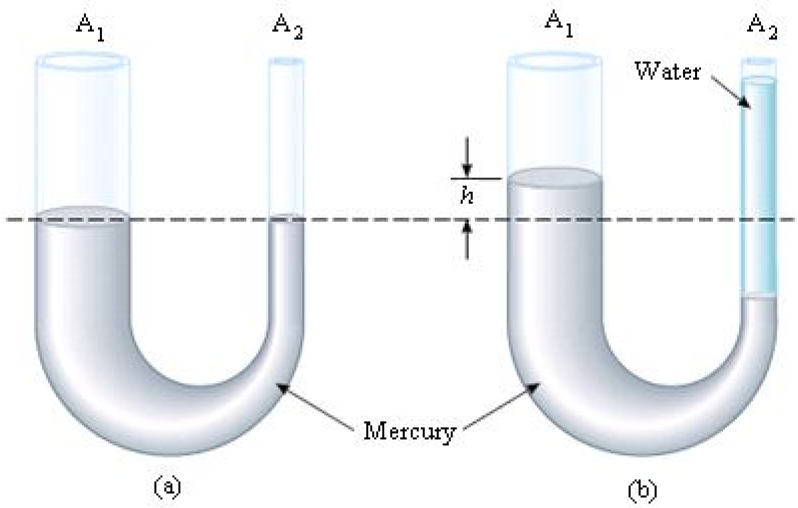

Figure 2

The left arm of the tube has cross-sectional area A_1 of 10.0 cm^2, and the right arm has a cross-sectional area A_2 of 5.00 cm^2. One hundred grams of water are then poured into the right arm as in Figure 2(b).

(i) Determine the length of the water column in the right arm of the U-tube. Use density of water = 1.00 g/cm^3. [4]

(i) Given that the density of mercury is 13.6 g/cm^3, what distance h does the mercury rise in the left arm? [4]

(c) A horizontal pipe 10.0 cm in diameter has a smooth reduction to a pipe 5.00 cm in diameter. If the pressure of the water in the larger pipe is 8.00 x 10^4 Pa and the pressure in the smaller pipe is 6.00 x 10^4 Pa, at what rate does water flow through the pipes? [4]

(d) A large storage tank, open at the top and filled with water, develops a small hole in its side at a point 16.0 m below the water level. If the rate of flow from the leak is equal to 2.50 x 10^{-3} m^3/min, determine:

(i) the speed, in m/s, at which the water leaves the hole, and [4]

(ii) the diameter of the hole. [2]

3. (a) A crate of mass 8.00 kg is pulled up a rough incline with an initial speed of 50 m/s. The pulling force is 100 N parallel to the horizontal floor. The incline makes an angle of 20° with the horizontal. The coefficient of kinetic friction is 0.400 and the crate is pulled 5.00 m.

(i) Distinguish between static and kinetic friction. [2]

(ii) How much work is done by the gravitational force on the crate? (Use g = 9.8 m/s^2) [2]

(iii) How much work is done by the 100N force on the crate? [4]

(iv) What is the change in kinetic energy of the crate? [2]

(v) What is the final velocity of the crate? [2]

(b) Draw a well labelled stress-strain diagram for an elastic material and explain the meaning of all important terms on the graph. [8]

4. (a) A thermosetting polymer 10.0 cm long, 2.00 cm wide and 0.500 cm thick is allowed to deflect 0.500 mm when a force of 500 N is applied. If its flexural modulus is 6.90 GPa, determine the maximum distance between its supports. Will the polymer fracture if its flexural strength is 85.0 MPa? [10]

(b) A vertical solid steel post of negligible weight 3.00 m long and 15.0 cm in diameter is required to support a hanging mass of 800 kg. If Young's Modulus for steel is 20.0 x 10^{10} Pa, find the:

(i) Stress and strain in the post. [6]

(ii) Change in the post's length when the load is applied. [4]

5. (a) What do you understand by mechanics and mechanical engineering? [4]

(b) With the aid of a diagram, classify the different fields of mechanics. [12]

(c) Giving appropriate examples of each, distinguish between a vector and a scalar. [4]

6. (a) What do you understand by the terms:

   (i) Inelastic collision [2]

   (ii) Internal energy [2]

   (iii) Temperature [2]

(b) A 1.50 kg bowling ball of moving in a straight line on a hard and smooth surface with a velocity of 5.00 m/s undergoes an elastic collision with an identical stationary ball. After collision the previously stationary ball moves with a velocity of 2.00 m/s making an angle of **α** with the line of motion of the bowled ball prior to collision. The bowled ball makes an angle of **β** with its previous line of motion and moves with a velocity $\mathbf{v_2}$.

   (i) Find $\mathbf{v_2}$, **α** and **β** [12]

   (ii) What **two** assumption have you made about the motion of both balls? [2]

7. (a) What do you understand by *projectile motion*? [2]

(b) A cannonball is shot out of a cannon with a horizontal velocity component of 40.0 m/s and a vertical velocity component of 20.0 m/s. If the cannon is sitting on top of a cliff 100 m high, find:

   (i) Draw a fully labelled diagram to illustrate this motion. [4]

   (ii) The range of the cannonball. [2]

   (iii) The cannonball's maximum height. [2]

(c) A ball is shot from the ground into the air. At a height of 10.0 m its velocity is given by:

$$\boldsymbol{v} = (7.50\boldsymbol{i} + 6.20\boldsymbol{j}) \text{ m/s}.$$

Assume air resistance is negligible.

   (i) To what maximum height does the ball rise? [3]

   (ii) What total horizontal length does the ball travel? [3]

   (iii) What is the magnitude and direction of the velocity just before touching the ground? [4]

8. (a) If **A** = (6.00***i*** – 8.00***j***) units, **B** = (–8.00***i*** + 3.00***j***) units, and **C** = (26.0***i*** + 19.0***j***) units, determine a and b such that a**A** + b**B** + **C** = 0. [2]

(b) The rectangle shown below has sides parallel to the *x* and *y* axes. The position vectors of two corners are A = 10.0 m at 50.0° and B = 12.0 m at 30.0°.

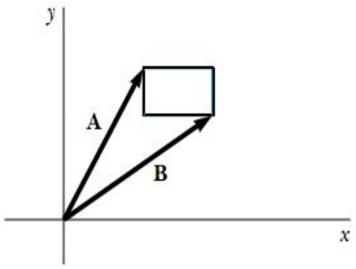

Figure 3

(i) What is the perimeter of the rectangle? [4]

(ii) Find the magnitude and direction of the vector from the origin to the upper right corner of the rectangle. [4]

(c) An inventive child named Sox wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected to a rope that passes over a frictionless pulley as shown in Figure 4.

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Figure 4

Sox pulls on the loose end of the rope with such a force that the spring scale reads 250 N. Sox's true weight is 320 N, and the chair weighs 160 N.

(i) Draw a free-body diagram for Sox and the chair considered as one system. [4]

(ii) Show that the acceleration of the system is upward and find its magnitude. [2]

(iii) Find the force Sox exerts on the chair. [4]