NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER EXAMINATIONS – MAY 2003
MECHANICAL ENGINEERING – SCH 2205
TIME – (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES
Answer **ANY FIVE** questions. Each question carries 20 marks.

---

1. (a) Define the following terms pertaining to the strength of materials:

   (i) Young's Modulus
   (ii) Shear Modulus
   (iii) Secant Modulus
   (iv) Tangent Modulus
   (v) Flexural Modulus (15 marks)

   (b) The flexural modulus of Alumina is 330GPa and its flexural strength is 350MPa. Determine the amount of deflection at the moment of breaking for an aluminium bar 7.6mm thick, 25mm wide and 250mm long. The bar is placed on supports 175mm apart. (5 marks)

2. (a) (i) Define the critical resolved shear stress. (3 marks)

   (ii) How is true strain different from engineering strain? (4 marks)

   (iii) What force must be applied in the [112] direction of a copper rod to produce a resolved force of 410N in the [110] direction? (5 marks)

   (b) State the equation relating the Young's Modulus, E, Bulk Modulus, B, and the Shear Modulus G. (8 marks)

3. (a) Three forces F_1, F_2 and F_3 act on a particle. If $F_1 = (-3i + 7j)$ Newtons; $F_2 = (i - j)$ Newtons and $F_3 = (Pi + qj)$ Newtons:

   (i) Given that the particle is in equilibrium, determine the values of p and q. (4 marks)

   (ii) The resultant of the forces F_1 and F_2 is R, calculate in Newtons the magnitude of the resultant R. (3 marks)

   (b) What acceleration is produced on a body of mass 2kg by the resultant of two forces $(4i + 2j)N$ and $(i - j)N$? (4 marks)

3 (c) Find the work done when a force $F = 4i + 3j + 5k$ moves a particle through a displacement of $i - 2j + k$. (4 marks)

(d) A particle at time t seconds has a position vector $(3ti + (t^2 + 1)j)m$. Find its speed and direction of motion when $t = 2$ seconds. (5 marks)

4. (a) A heavy goods train starts from rest and accelerates uniformly for 4 minutes until it achieves a velocity of 36km/hr. It runs at this speed for 5 minutes and then accelerates uniformly coming to rest in 2 minutes.

(i) Sketch the velocity time graph. (4 marks)
(ii) What is the total distance moved? (3 marks)
(iii) What was the rate of acceleration? (3 marks)

(b) A lift ascends with a constant acceleration, a, then travels with a constant speed and is finally brought to rest under a constant retardation, a. If the total distance travelled is h, and the total time taken is t, show that the total time spent travelling at constant is;

$$\left(t^2 - \frac{4h}{a}\right)^{\frac{1}{2}}$$

(10 marks)

5. (a) Two bodies A and B of masses m_1 and m_2 respectively are connected by a light in extensible string passing over a smooth pulley. If $m_1 > m_2$;

(i) Find the acceleration of the bodies and; (3 marks)

(ii) Show that the tension in the string is; (3 marks)

$$\frac{2m_1 m_2 g}{m_1 + m_2}$$

(iii) If m_2 is lying on a rough horizontal surface and m_1 hanging freely over a smooth pulley and the coefficient of friction is μ, show that the condition for motion to occur is $m_1 > \mu m_2$. (5 marks)

(b) Find the power needed to raise water 10m from a well and discharge it through a hose of cross-sectional area $50cm^2$ at 5m/s. (5 marks)

6. A uniform ladder of length 2m and mass 20kg leans against a smooth wall supported on a rough floor. The ladder is inclined at θ to the vertical. The ladder is about to slip when $\theta = 30^o$.

(i) Find the coefficient of friction between the ladder and the floor. (8 marks)

(ii) If $\theta = 25^o$, find how far a man weighing 70kg can climb before the ladder slips. (8 marks)

END OF PAPER!!!