NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF TEXTILE TECHNOLOGY

END OF SECOND SEMESTER EXAMINATIONS - AUGUST 2009

TXT 1209 – APPLIED MECAHNICS

TIME: 3 HOURS

INSTRUCTIONS

Answer **ANY FIVE** questions. Each question carries **20 marks.**

QUESTION 1

(a) Show that the following equation is dimensionally consistent.

$P + 1/2\rho v^2 + \rho gy$ constant

Where ρ = density, v = velocity, g = acceleration; p = pressure; y = height **(4)**

(b) Define the following terms giving the appropriate S.I. unit for each

(i) Viscosity **(1)**
(ii) Young's Modulus, **(1)**
(iv) Stress **(1)**
(v) Strain **(1)**

(c) A stone is thrown from the top of a building is given an initial velocity of 20.0m/s straight upwards. The building is 50.0m high, and the stone just misses the edge of the roof on its way down.

Determine:-

(i) The time needed for the stone to reach its maximum height. **(2)**
(ii) The maximum height. **(2)**
(iii) The time needed for the stone to return to the top of the building. **(2)**
(iv) The velocity of the stone at this instant. **(2)**
(v) The velocity and position of the stone at t= 5.00s. **(4)**

QUESTION 2

(a) Ethanol has a density $\rho = 791 kg/m^3$ and it flows smoothly through a horizontal pipethat tapers in cross sectional area from $A_1 = 1.20 \times 10^{-3} m^2$ to $A_2 = A_1/2$. The pressure difference between the wide and narrow sections of pipe is 4120Pa. What is the volume flow rate R_v of the ethanol? **(5)**

(b) A ball is tossed from an upper story window of a building. The ball is given an initial velocity of 8.00m/s at an angle of 20.0^0 below the horizontal. It strikes the ground 3.00s later.

(i) How far horizontally from the base of the building does the ball strike the ground? **(3)**

(i) Find the height from which the ball was thrown. **(4)**

(ii) How long does it take the ball to reach a point 10.0m below the level of launching? **(4)**

(c) Consider two vectors **A** = 3**i** – 2**j** and **B** = -i – 4**j.** Calculate:

(i) A + B **(2)**

(ii) A – B **(2)**

QUESTION 3

(a) A crate of mass 10.0kg is pulled up a rough incline with an initial speed of 50m/s. The pulling force is 100N parallel to the incline which makes an angle of 20^0 with the horizontal. The co efficient of kinetic friction is 0.400 and the crate is pulled 5.00m.

(i) How much work is done by the gravitational force on the crate? **(2)**

(ii) Determine the increase in the internal energy due to friction. **(2)**

(iii) How much work is done by the 100N force on the crate? **(2)**

(iv) What is the change of the kinetic energy on the crate? **(2)**

(v) What is the speed of the crate after being pulled 5.00m? **(2)**

(b) Draw a well labeled stress- strain diagram for a material of your choice. Explain the meaning of all important terms on the graph. **(4)**

(c) Explain the meaning of the following terms:

(i) Elastic collision **(2)**

(ii) Internal energy **(2)**

(iii) Temperature **(2)**

QUESTION 4

(a) A nylon tennis string on a racquet is under tension of 250 N. If it has a diameter

of 1.00 mm, by how much is it lengthened from its un-tensioned length of 30.0cm? (Young's modulus for nylon is 5 x 10^9 N/m^2). **(2)**

(b) A Puck of mass 0.5kg moves along the **x** axis with a velocity of 4.00m/s. It collides elastically with another stationary Puck. After the collision the first Puck moves with a velocity of 2.00m/s making an angle **α** with the horizontal. The other Puck makes an angle **β** below the horizontal and moves at a velocity V_2.

(i) Find V_2 and **(5)**

(ii) α and β **(6)**

(c) A ball is thrown vertically upward with an initial speed of 19.6 m/s. Sketch a graph for:

(i) The position, **(2)**
(ii) Velocity, and **(2)**
(iii) Acceleration of the ball for the first five seconds of its motion. **(3)**

QUESTION 5

(a) A 5.0kg block is set into motion up an inclined plane with an initial speed of 8.00m/s. The block comes to rest after travelling 3.0m along the plane, which is inclined at an angle of 30^0 to the horizontal.
Determine:-

(i) The change in the block's kinetic energy. **(2)**
(ii) The change in its potential energy. **(2)**
(iii) The frictional force exerted on it (assumed to be constant). **(2)**
(iv) What is the coefficient of kinetic friction? **(2)**

(b) A water hose 2.00cm in diameter is used to fill a 20.0liter bucket. If it takes 1.00min to fill the bucket, what is the speed v at which the water leaves the hose? If the diameter of the hose is reduced to 1.00cm, what will the speed of the water be as it leaves the hose, assuming the same flow rate? **(8)**

(c) A 3.0kg mass undergoes an acceleration given by a = (2.0i + 5.0j). Find the resultant for **F**, and its magnitude. **(4)**

(a). A vertical solid steel post 15cm in diameter and 3.00m long is required to support a load of 800kg. The weight of the pole can be neglected. (Young's Modulus for steel: 20 x 10^{10}Pa)

What is?

(i) The stress in the post. **(4)**

(ii) The strain on the post. **(2)**

(iii) The change in the post's length when the load is applied. **(4)**

(b) A hydraulic press contains $0.25m^3$ of oil. Find the decrease in the volume of the oil when it is subjected to a pressure increase of 1.6×10^7 Pa. The bulk modulus of the oil is $B = 5.0 \times 10^9$Pa and its compressibility is $K = 20 \times 10^{-6}atm^{-1}$. **(4)**

(c) A car travelling at a constant speed of 30.0m/s passes a trooper hidden behind a billboard. One second after the speeding car passes the billboard, the trooper sets in chase after the car with a constant acceleration of $3.00m/s^2$. How long does it take the trooper to overtake the speeding car? **(6)**

QUESTION 6

(a) A water pipe having a 2.5cm inside diameter carries water into the basement of a house at a speed of 0.90m/s and a Pressure of 170kPa. If the pipe tapers to 1.2cm and rises to the second floor 7.6m above the input point, what are?

(i) The speed **(4)**

(ii) The water pressure at the second floor? **(4)**

(c) Write down an expression for the work energy system for non-conservative system. **(2)**

(d) A 3.0kg mass starts from rest and slides a distances **d** down a frictionless 30^0 incline, where it contacts an unstressed spring of negligible mass. The mass slides an additional 0.20m as it is brought momentarily to rest by compressing the spring (k = 400N/m). Find the initial separation **d** between mass and spring. **(3)**

(e) An unstable nucleus of mass 17×10^{-27} kg initially at rest disintegrates into three particles. One of the particles, of mass 5.0×10^{-27} kg, moves along the **y** axis with a speed of 6.0×10^6m/s. Another particle, of mass 8.4×10^{-27} kg moves along the **x** axis with a speed of 4.0×10^6m/s. Find:

(i) The velocity of the third particle. **(3)**

(ii) The total energy given off in the processes. **(3)**

END OF QUESTION PAPER