UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2009/10

TITLE O F PAPER: INTRODUCTORY PHYSICS I

COURSE NUMBER: P101

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR OUT OF FIVE QUESTIONS

EACH QUESTION CARRIES 25 MARKS

MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN

GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW THE EQUATIONS USED WERE OBTAINED

THIS PAPER HAS SEVEN PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS DATA THAT MAY BE USEFUL IN SOME QUESTIONS

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE CHIEF INVIGILATOR

QUESTION 1

(a) A body reaches the origin with a velocity of 4 m/s and accelerates to 14 m/s in 5 s, and then moves at constant velocity for 5 s after which it accelerates to - 1 m/s in 5 s. Sketch

(i) the velocity-time, **(4 marks)**

(ii) the acceleration-time, and **(5 marks)**

(iii) the distance-time graphs for this motion. **(6 marks)**

(b) A fireman stands on top of a roof 5 m high with the water hose making an angle of 45° with the horizontal. The water leaves the hose with a velocity of 50 m/s and hits a window at the highest point of its trajectory.

(i) How high above ground is the window? **(4 marks)**

(ii) Find the time the water spends in air from the hose to the window? **(3 marks)**

(iii) What is the horizontal distance of the window from the fireman? **(3 marks)**

QUESTION 2

(a) The system shown in Figure 1 moves such that m_3 moves downward and m_2 and m_3 move up the inclined planes to the right. Neglect the masses of the cords and assume the pulleys are frictionless and have negligible mass. The coefficient of friction between all surfaces is μ.

(i) Make a resolved force diagram for each body from which useful equations of motion can be obtained. **(4 marks)**

(ii) Write down the equations of motion for each body. **(6 marks)**

(iii) Determine the expression for the acceleration of the system. **(5 marks)**

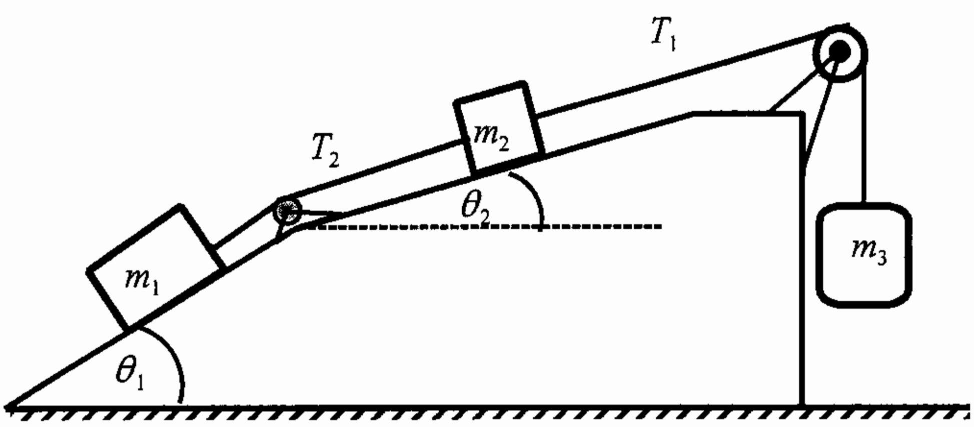

Figure 1.

(b) The system shown in Figure 2 is in equilibrium. The beam is uniform, 10 m long, and weighs 1500 N. The cable is attached to the beam at a distance of 6 m from the wall, and the mass m_1 on the beam is centred at 2 m from the wall.

(i) Find the tension in the cable. **(7 marks)**

(ii) Find the x- and y-components of the reaction force by the wall. **(3 marks)**

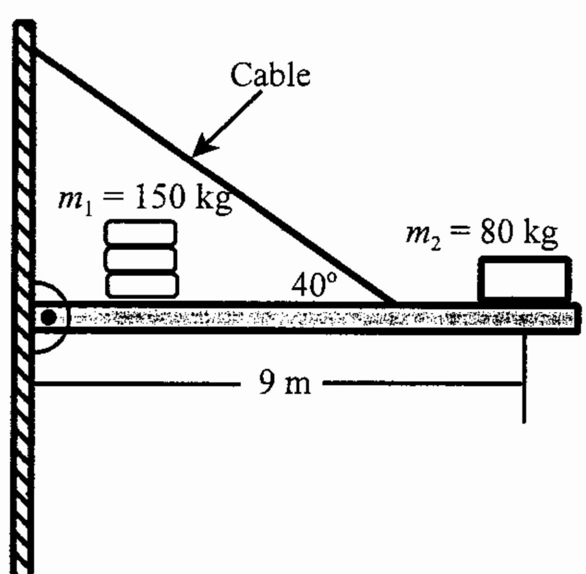

Figure 2.

QUESTION 3

(a) The system in Figure 3 is released from rest with the 10 kg block 6 m above the floor. Use energy methods to find the velocity with which the 40 kg block hits the floor. Neglect friction and assume that the mass of the pulley and rope are negligible. **(8 marks)**

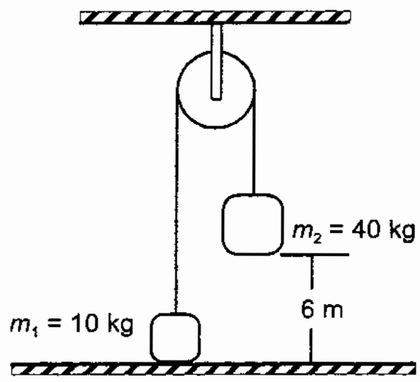

Figure 3.

(b) A body of mass $m = 5$ kg is attached to a horizontal spring of spring constant $k = 50$ N/m. The spring is compressed a distance of 10 cm with the mass. The surfaces are frictionless. After the system is let go, what is the velocity of the mass when the spring returns to its original length? **(5 marks)**

(c) A truck of mass $M_T = 5000$ kg moving north at a velocity $\upsilon_T = 100$ km/h collides with a car of mass $m_c = 1200$ kg moving east at a velocity of $\upsilon_c = 160$ km/h. The two vehicles end up as one wreckage. Neglect friction and any means to avoid the accident by either drive.

(i) Make a sketch of the problem which shows what happens before and after the collision. **(2 marks)**

(ii) Find the angle θ, the wreckage makes just after the collision. **(8 marks)**

(iii) Find the speed of the wreckage just after the collision. **(2 marks)**

QUESTION 4

(a) A mass $m = 5$ kg located at a distance of 1.5 m from the axis of rotation is rotated at 5.5 rad/s from a rod of negligible mass.

(i) What is the centripetal force on the mass? **(3 marks)**

(ii) What is the moment of inertia of the mass about the axis of rotation? **(2 marks)**

(iii) What is the rotational kinetic energy of the mass? **(2 marks)**

(iv) What toque would bring the system to rest in 5 s? **(4 marks)**

(b) A disc with a moment of inertia $I_1 = 125$ kg.m^2 is rotating with angular velocity $\omega_0 = 900$ rpm is brought in contact with a stationary disk of moment of inertia $I_2 = 75$ kg.m^2 such that their axis of rotation coincide. What is the final angular velocity (in rad/s) reached by the two discs? **(6 marks)**

(c) A square steel wire of sides 1.75 mm and a length of 2.4 m supports a load of 25 kg within the proportional region. The Young's modulus for the wire is 4.267×10^{10} N/m^2.

(i) What is the stress on the wire? **(4 marks)**

(ii) What is the strain on the wire? **(2 marks)**

(iii) By how much does the wire stretch under the load? **(2 marks)**

QUESTION 5

(a) Discuss with the aid of a diagram and equations how a mercury barometer is used to measure atmospheric pressure. **(6 marks)**

(b) A wooden cube of density 650 kg/m^3 and sides 1.5 m is placed in water. A 50 kg load is placed on the cube. Find the height above the water of the top surface of the cube. **(6 marks)**

(c) In an insulated vessel, 250 g of ice at 0°C is added to 600 g of water at 18°C.

(i) Show by finding the heat required to melt all the ice and the heat required to cool the water to 0°C, that only part of the ice melts, leaving an ice bath of water and ice. **(5 marks)**

(ii) How much ice remains when the system reaches equilibrium? **(4 marks)**

(d) An ideal gas at a pressure of 2.5 atmospheres at a temperature of 25°C is heated at constant volume so that its pressure rises to 8 atmospheres. What is the final temperature reached by the system? **(4 marks)**

GENERAL DATA SHEET

Speed of light in vacuum, $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 334 m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant, $G = 6.67 \times 10^{-11}$ N m^2/kg^2
Density of mercury = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013×10^5 Pa
Gas constant, $R = 8.314$ J/(K mol)
Avogadro's number, $N_A = 6.022 \times 10^{23}$ mol^{-1}
Threshold of hearing, $I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J
Specific heat capacity for water, $c_w = 4186$ J/(kg K)
Specific heat capacity for ice, $c_i = 2090$ J/(kg K)
Specific heat capacity for steam, $c_s = 2079$ J/(kg K)
Latent heat of fusion for ice, $L_f = 3.33 \times 10^5$ J/kg
Latent heat of vapourisation for water $L_v = 2.260 \times 10^6$ J/kg
Coulomb's constant, $k_e = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ Nm^2/C^2
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass, $m_n = 1.675 \times 10^{-27}$ kg