UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2007

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) Given the vectors $\vec{A} = 2\hat{i} - 3\hat{j} + 5\hat{k}$ and $\vec{B} = -2\hat{i} + 4\hat{j} - 3\hat{k}$, find

(i) the magnitudes of vectors $\vec{A}$ and $\vec{B}$, **(2 marks)**

(ii) the dot product of vectors $\vec{A}$ and $\vec{B}$ $(\vec{A} \bullet \vec{B})$, **(2 marks)**

(iii) the angle between vectors $\vec{A}$ and $\vec{B}$, **(2 marks)**

(b) A body with an initial velocity of 2 m/s is accelerated at 4 m/s^2 for 4 s. It then moves at constant velocity for 4 s after which it is accelerated at -4 m/s^2 for 5 s. Sketch

(a) the acceleration-time graph, **(4 marks)**
(b) the velocity-time graph, and **(5 marks)**
(d) the distance-time graph for this motion. **(6 marks)**

(c) A body is projected from a height of h = 2 m with a velocity u_0 = 50 m/s, at an angle θ of 35° with the horizontal. Determine the maximum height H reached by the body. **(4 marks)**

QUESTION 2

(a) The three blocks in Figure 1 are connected by strings of negligible mass that pass over frictionless pulleys. The coefficient of kinetic friction between the masses m_2 and m_3 is 0.5. The acceleration of the system is to the right.

(i) Make resolved force diagrams for the three masses. **(4 marks)**
(ii) Write down the force equations for each mass. **(5 marks)**
(iii) Find the acceleration of the system. **(4 marks)**
(iv) Find the tension in each string. **(2 marks)**

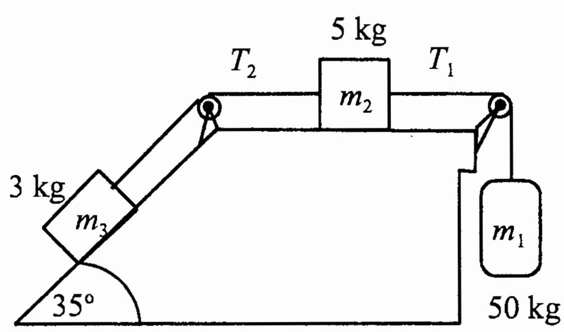

Figure 1.

(b) The system shown in Figure 2 is in equilibrium. The beam is uniform, 10 metres long, and weighs 200 N. Determine

(i) the tension in the cord, **(7 marks)**
(ii) the *x*- and *y*-components of the reaction force by the wall, and **(3 marks)**

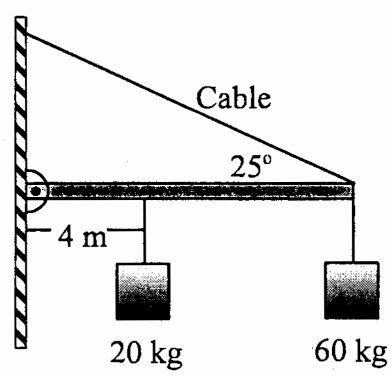

Figure 2.

QUESTION 3

(a) The system in Figure 3 is released from rest with the 20 kg block 5 m above the floor. Use the principle of conservation of energy to find the velocity with which the 50 kg block hits the floor. Neglect friction and assume that the mass of the pulley is negligible. **(6 marks)**

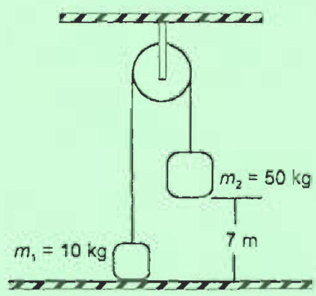

Figure 3.

(b) In a rural clinic, water is pumped from a borehole 5 m deep into a tank with an inlet 6 m from the ground. The water is ejected with a velocity of 0.2 /s at a rate of 4 itres per minute.

(i) How much potential energy is given to the water per minute? **(2 marks)**
(ii) How much kinetic energy is given to the water per minute? **(2 marks)**
(iii) What is the power of the pump? **(2 marks)**

(c) A billiard ball *B* rests on a frictionless table and is struck by a second billiard ball *A* of the same mass *m*, which is originally traveling at υ_A = 20 m/s and is deflected at an angle θ_A = 30° from its original direction with a speed υ_A', while Billiard ball *B* acquires a velocity υ_B' at an angle θ_B = 40° with the original velocity of billiard ball *A*. (See Figure 4.)

(i) Find the speed of each billiard ball after the collision. **(10 marks)**
(ii) Is the collision perfectly elastic? **(3 marks)**

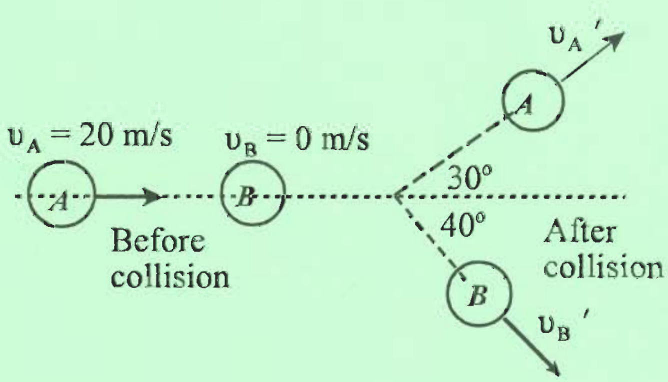

Figure 4.

QUESTION 4

(a) A wire of length 2 m and a cross-sectional area of 0.5 cm^2 supports a load of 50 kg within the proportional region. The wire stretches by 0.5 mm.

(i) What is the stress on the wire? **(2 marks)**

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

(iii) What is the Young's modulus for the wire? **(2 marks)**

(b) The liquid in the open tube manometer shown in Figure 5 is mercury. What is the gauge pressure of the gas in the tank? **(6 marks)**

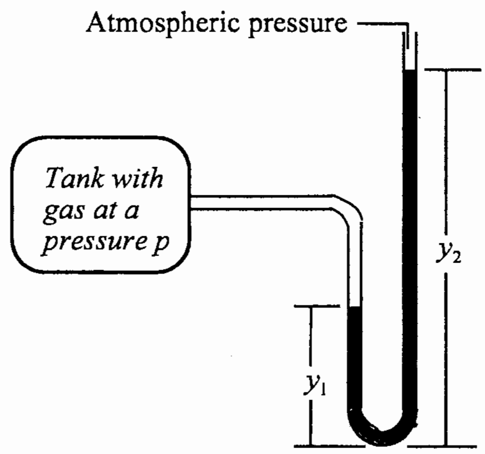

Figure 5.

(c) A block of wood has sides of length *a* = 50 cm, *b* = 40 cm and *c* = 30 cm and a density of 680 kg/m^3. It floats in sea water of density 1025 kg/m^3, with one a the faces with edges of length *a* and *b* facing upwards. What is distance *h* from the bottom of the block to the water surface? **(5 marks)**

(d) A sealed tank contains water for a fire hydrant to a level of 8 m. Above the water level there is pressurised air at a pressure of 7 atmospheres. A hose is connected at the bottom of the tank used to extinguish fires. Suddenly the hose breaks off from the tank. Use Bernoulli's equation to determine the velocity with which the water comes out at the bottom of the tank. Show your working and state all assumptions made. **(8 marks)**

QUESTION 5

(a) Discuss how a thermoflask works to prevent heat transfer between its contents and the surroundings. **(8 marks)**

(b) A metal block of mass 500 g at 130 °C is placed into 200 g copper cylinder containing 400 g of water at 22 °C. The final temperature of the system is 35 °C. The specific heat capacity of copper is 385 J/(kgK). What is the specific heat capacity of the metal block? Neglect heat losses to the surroundings. **(8 marks)**

(c) Two moles of an ideal gas at a pressure of 1 atmosphere and a temperature of 20 °C, are heated at constant volume to a pressure of 3 atmospheres. The tank containing the gas is made if a metal that melts at 450 °C. Determine whether this process is possible. Hint, find the temperature at which the pressure rises to 3 atmospheres. **(5 marks)**

(d) Three moles of nitrogen at krypton 5 atmospheres are stored at 300 K.

(i) What is the volume of the gas? **(2 marks)**

(ii) If the gas is compressed at constant temperature until the pressure drops to 1 atmosphere, what is the new volume? **(2 marks)**

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 343 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}
$I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c(*water*) = 4186 J/(kg K) c(*ice*) = 2090 J/(kg K) c(*steam*) = 2079 J/(kg K)
L_f(*ice*) = 3.33×10^5 J/kg L_v(*water*) = 2.260×10^6 J/kg

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

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