UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2006

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 $\vec{A} = -\hat{i} + 3\hat{j} + 2\hat{k}$ and $\vec{B} = 4\hat{i} - 2\hat{j} + 3\hat{k}$, find the cross product ($\vec{A} \times \vec{B}$) of the two vectors. **(4 marks)**

(b) A body starts at 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 - 6 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)**

(c) A projectile is shot at an angle of 45° with the horizontal with a velocity of 50 m/s and lands on a roof just when reaches its normal maximum height, i,e at the turning point.

(i) What is the maximum height reached? **(4 marks)**
(ii) How much time does it take to reach the highest point? **(2 marks)**

QUESTION 2

(a) In Figure 1, m_1 is 4 kg and m_2 is 3 kg. A force F is applied as shown such that m_1 moves up the inclined plane with an acceleration of 2 m/s. The mass of the string and the friction in the pulley are negligible. The coefficient of kinetic friction μ_k between m_1 and the horizontal surface is 0.4.

(i) What is the magnitude of the applied force F? **(5 marks)**
(ii) What is the tension in the string? **(2 marks)**
(iii) What would be the coefficient of kinetic friction if the system moved at constant velocity and the force F obtained in (a) was applied? **(4 marks)**

(b) The system shown in Figure 2 is in equilibrium. The beam is uniform, 10 m long, and weighs 2000 N. The bags of cement are 2.5 m from the wall and have a mass of 300 kg.

(i) Determine the tension in the cord. **(6 marks)**
(ii) Find the x- and y-components of the reaction force by the wall. **(3 marks)**
(iii) Write down the force by the wall in vector form. **(1 mark)**
(iv) What is the magnitude of the force by the wall? **(1 mark)**
(v) Find the angle the reaction force makes with the horizontal and illustrate the angle. **(3 marks)**

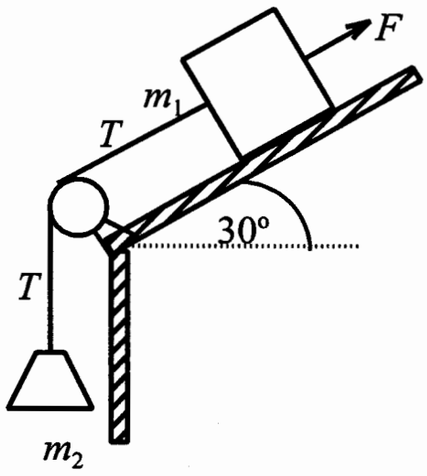

Figure 1.

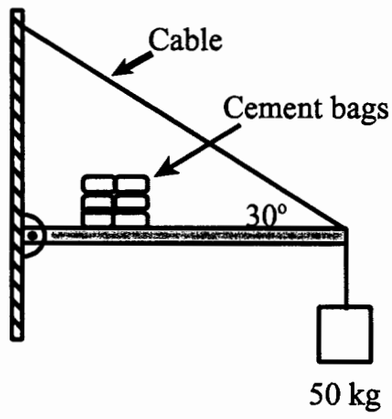

Figure 2.

QUESTION 3

(a) A body is projected upward with a velocity of 50 m/s. Use energy methods to determine

(i) its maximum height, and **(4 marks)**

(ii) its velocity at a height of 10 m. **(4 marks)**

(b) A bullet of mass m = 90 g moving with an initial speed v_0 = 450 m/s strikes a stationary block of mass M = 2 kg and passes through the block with a velocity v_f as shown in Figure 3. The block acquires a velocity of 1.5 m/s after the impact. What is the final velocity of the bullet v_f? **(6 marks)**

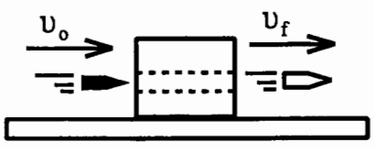

Figure 3.

(c) A flywheel of moment of inertia I = 125 kg m^2 is accelerated from an initial angular velocity of 800 rpm (revolutions per minute) to a final angular velocity of 5000 rpm in 5 s.

(i) What is the angular acceleration of the wheel? **(5 marks)**

(ii) What is the torque on the wheel during the acceleration period? **(1 mark)**

(iii) What angle does it turn through in the first 5 s? **(2 marks)**

(iv) What is the kinetic energy of the wheel at t = 5 s? **(1 mark)**

(v) If the flywheel has a radius of 25 cm, what is the centripetal force on mass of 500 g attached at the circumference of the wheel at t = 5 s? **(2 marks)**

QUESTION 4

(a) A circular steel wire of length 1.8 m and a radius of 0.5 mm supports a load of 50 kg within the proportional region. Under this load the final length of the wire is 1.8025 m.

(i) What is the stress on the wire? **(3 marks)**
(ii) What is the strain on the wire? **(2 marks)**
(iii) What is the Young's modulus for the wire? **(2 marks)**

(b) On a certain day the height *h* of the mercury column in a barometer is 76.1 cm. What is the atmospheric pressure on such a day? The density of mercury is 13.6×10^3 kg/m^3. Show with the aid of a diagram how you obtain your solution. **(5 marks)**

(c) State Pascal's law and give an example of its application in everyday life. **(4 marks)**

(d) State Archimedes principle. **(2 marks)**

(e) A First Year Science student of mass 60 kg relaxes on a Styrofoam slab 10 cm thick floating in a pool of fresh water. The slab floats with its top surface just at the level of the water. The density of the Styrofoam is 300 kg/m^3. What is the area of the slab? **(7 marks)**

QUESTION 5

(a) A sealed tank contains water for a fire hydrant to a level of 10 m. Above the water level there is pressurised air at a pressure of 6 atmospheres. The 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 initially comes out at the bottom of the tank. State all assumptions made. **(10 marks)**

(b) A metal block of mass 250 g at 150 °C is placed into a well insulated copper cylinder of mass 150 g containing 400 g of water at 20 °C. The final temperature of the system is 30 °C. The specific heat capacity of copper is 385 J/(kgK). What is the specific heat capacity of the metal block? **(9 marks)**

(c) Ten moles of an ideal gas at 3 atmospheres and 300 K are expanded at constant temperature until the pressure drops to 1 atmosphere.

(a) What is the initial volume of the gas? **(2 marks)**
(b) What is the final volume of the gas? **(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}
$I_0 = 10^{-12}$ 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