UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2007/08

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) Given the vectors $\vec{A} = \hat{i} + 2\hat{j} + 3\hat{k}$ and $\vec{B} = 4\hat{i} + 5\hat{j} + 6\hat{k}$, find

i. the dot product of the two vectors, and **(3 marks)**

ii. the cross product $\vec{A} \times \vec{B}$. **(4 marks)**

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

i. the acceleration-time graph, **(4 marks)**

ii. the velocity-time graph, and **(5 marks)**

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

c. A body is shot vertically upward with a velocity of 30 m/s. What is its height at time $t = 5$ s? **(3 marks)**

QUESTION 2

a. The two blocks $m_1 = 20$ kg and $m_2 = 4$ kg lie on inclined planes at angles $\theta_1 = 45°$ and $\theta_2 = 25°$ as shown in Figure 1 and are connected by cords of negligible mass that pass over a frictionless pulley. The coefficient of kinetic friction between all surfaces is the same and is $\mu = 0.5$. The acceleration of the system is to the right.

i. Make a resolved force diagram for each body. **(4 marks)**

ii. Write down the equations of motion for each body. **(4 marks)**

iii. Find the acceleration a of the system. **(6 marks)**

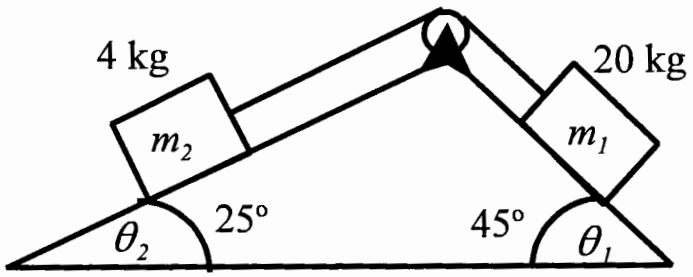

Figure 1.

b. The systems shown in Figure 2 is in equilibrium. The beam is uniform, 12 metres long, and weighs 2000 N.

i. Determine the tension in the cord. **(7 marks)**

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

iii. What is the mass m_2? **(2 marks)**

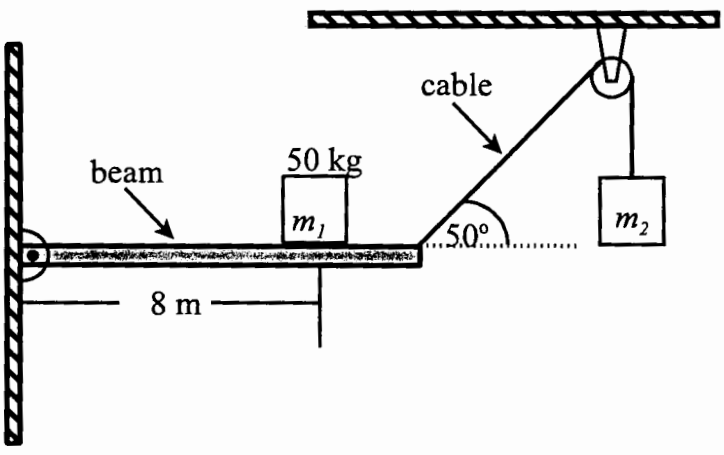

Figure 2.

QUESTION 3

a. The system in Figure 3 is released from rest with the 50 kg block 6 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)**

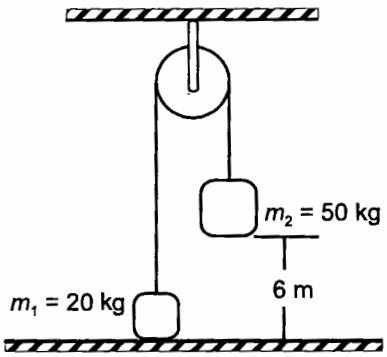

Figure 3

b. A First Year student eats a breakfast rated at 1800 food Calories. She wishes to do an equivalent amount of work by lifting a 30 kg mass up a distance of 30 cm so that she does not gain extra weight. Assume that the student does not use any energy to lower the mass each time.
   i. How many times must she lift the mass to loose the energy consumed? **(4 marks)**
   ii. Explain whether this can be realistic? **(2 marks)**

c. A bullet of mass m = 100 g moving with an initial speed υ_0 = 450 m/s strikes a stationary block of mass M = 5 kg. After the collision the block attains a velocity of V' = 10 m/s in the original direction of the bullet.
   i. What is the final velocity of the bullet υ_f? **(6 marks)**
   ii. Determine what type of a collision this is? **(2 marks)**

d. A flywheel of moment of inertia I = 125 kg m^2 is under a torque of 20 Nm.
   i. What is the angular acceleration of the wheel? **(1 mark)**
   ii. What is the angular velocity of the body at t = 5 s? **(2 marks)**
   iii. What angle does it turn through in the first 5 s? **(2 marks)**

QUESTION 4

a. A circular steel wire of length 2.2 m and a cross-sectional area of 1.00×10^{-5} m^2 supports a load of 50 kg within the proportional region. The wire stretches 7.5 mm under the load.
   i. What is the stress on the wire? **(2 marks)**
   ii. What is the strain on the wire? **(1 mark)**
   iii. What is the Young's modulus for the wire? **(1 mark)**

b. The liquid in the open tube manometer shown in Figure 4 is mercury, $y_1 = 18$ cm and $y_2 = 60$ cm.
   i. What is the absolute pressure P_{abs} of the gas in the tank? **(6 marks)**
   ii. What is the gauge pressure P_g of the gas in the tank. **(1 mark)**

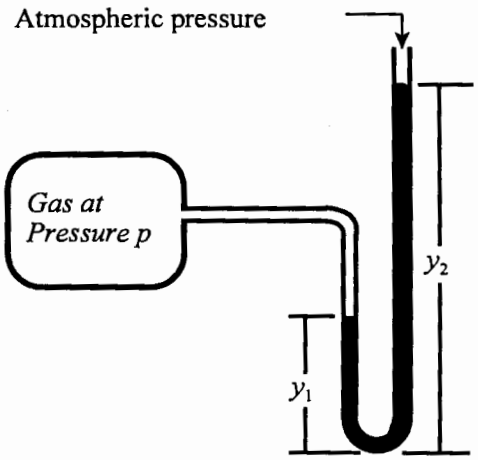

Figure 4.

c. A cube of wood has sides of length $l = 30$ cm, and a density of 650 kg/m^3. It floats in sea water of density 1025 kg/m^3. Determine the height of the top surface of the cube above the water? **(7 marks)**

d. An open tank contains water to a level of 30 m. A small hole develops at the bottom of the tank. Use Bernoulli's equation to determine the velocity with which the water comes out at the hole. State all assumptions made. **(7 marks)**

QUESTION 5

a. On a day when the temperature is 35 °C in Swaziland, what is the temperature in the Fahrenheit scale? **(3 marks)**

b. Steam of mass $m_s = 150$ g at a temperature $T_s = 120$ °C is bubbled through water of mass $m_w = 8$ kg at a temperature $T_w = 20$°C in a perfectly insulating container. All the steam condenses into water. Determine the final equilibrium temperature T_f reached by the system? **(9 marks)**

c. How is heat transfer minimised in a thermoflask? **(7 marks)**

d. Two moles of oxygen at a pressure of 1 atmosphere and a temperature of 20 °C, are heated at constant volume to a pressure of 4.5 atmospheres. The tank containing the gas is made of a metal that melts at 450 °C. Determine whether this process is possible. Hint, find the temperature at which the pressure rises to 4.5 atmospheres. **(6 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