UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

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

(i) A and B, the magnitudes of vectors, **(2 marks)**

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

(iii) the angle between the two vectors. **(3 marks)**

(b) Using the dot product, how can you tell if two vectors are parallel? **(2 marks)**

(c) A body with an initial velocity of 2 m/s at the origin, is accelerated at 2 m/s^2 for 3 s. It then moves at constant velocity for 5 s after which it is accelerated at -2 m/s^2 for 6 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)**

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 μ between all surfaces is the same. The acceleration of the system is 1.89 m/s^2 to the right.

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

(ii) Write down the equations of motion for each body. **(5 marks)**

(iii) Find the coefficient of kinetic friction between the blocks m_2 and m_3, and the surfaces, assuming that it is the same for both. **(7 marks)**

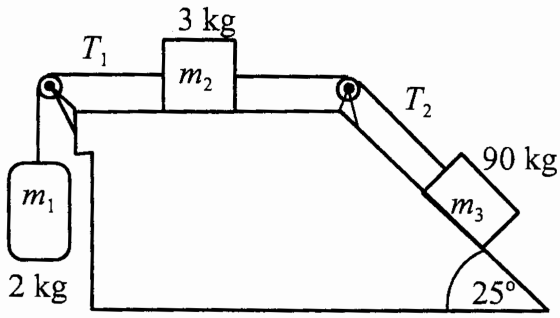

Figure 1.

(b) The systems shown in figure 2 is in equilibrium. The beam is uniform, 8 metres long, and weighs 500 N.

(i) Determine the tension in the cord. **(6 marks)**

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

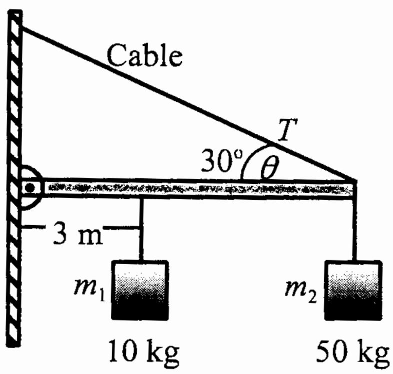

Figure 2.

QUESTION 3

(a) A body of mass m = 500 g is projected upward with a velocity of 80 m/s. Use energy methods to determine

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

(ii) its kinetic energy at a height of 100 m. **(3 marks)**

(b) A university student pulls a suit case of mass $m = 15$ kg with wheels at constant speed by a strap which makes an angle $\theta = 40°$ above the horizontal. The coefficient of kinetic friction μ between the wheels of the suitcase and the surface is 0.5. The suite is pulled for a distance $d = 75$ m on a flat surface. Find the work done by the student? **(6 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 velocity $\upsilon_0 = 20$ m/s and billiard ball *A* is deflected at an angle $\theta_A = 25°$ from its original direction with a speed $\upsilon_A' = 5$ m/s as shown in Figure 3. Billiard ball *B* acquires a velocity υ_B' at an angle θ_B with the original velocity of billiard ball *A*.

(i) Find the angle θ_B. **(10 marks)**

(ii) Find the velocity of billiard ball *B*, υ_B' after the collision. **(2 marks)**

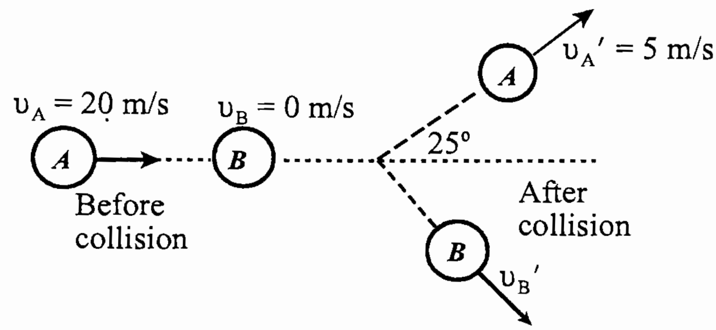

Figure 3.

QUESTION 4

(a) A steel wire has the following properties:

length = 8 m

cross section = 3.14×10^{-4} m^2.

Young's modulus = 1.8×10^{11} Pa

Proportional limit = 3.6×10^{8} Pa

The wire is fastened at its upper end and hangs vertically with a mass *m* suspended from it.

(i) What is the mass if the wire stretches to the proportional limit? **(2 marks)**

(ii) How much does the wire stretch at the proportional limit? **(3 marks)**

(b) In a certain day the height *h* of the mercury column in the barometer is 75.9 cm. What is the atmospheric pressure on such a day? Make a diagram of the barometer and show clearly how your answer is obtained. **(7 marks)**

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

(d) A sealed tank contains water for a fire hydrant to a level of 15 m. Above the water level there is pressurised air at a pressure of 8 atmospheres. A hose used to extinguish fires is connected at the bottom of the tank. 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. State all assumptions made. **(9 marks)**

QUESTION 5

(a) On a day when the temperature is 85 °F in North America, what is the temperature in the Celsius scale? **(3 marks)**

(b) Ice of mass $m_i = 500$ g at temperature of minus $T_i = 2$ °C is added to $m_w = 5$ kg of water at a temperature of $T_w = 25$ °C in an insulated container. All the ice melts. Determine the final temperature T_f of the system. **(10marks)**

(c) Sketch a volume versus temperature diagram for water to illustrate the nature of water that makes containers filled with water break when frozen. An briefly discuss why water behave this way. **(6 marks)**

(d) A rod of glass is 30 cm long and has a diameter of 1.5 cm and the thermal coefficient of linear expansion of the material is $\alpha = 9 \times 10^{-6}$ °C. The temperature of the rod is increased by 65 $°C^{-1}$.

(i) What is the change in length and radius of the rod in micro metres? **(3 marks)**

(ii) Find the approximate increase in volume? State the approximation made. **(3 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