UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006/07

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

(b) A body leaves the origin with a velocity of 2 m/s and accelerates to 18 m/s in 4 s, and then moves at constant velocity for 5 s after which it accelerates to - 2 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 soccer player tries to score a header by heading the ball from a height $h = 2$ m to a goal post a horizontal distance $R = 6$ m away. The initial velocity of the ball is $\upsilon_0 = 10$ m/s and makes an angle $\theta = 37°$ with the horizontal. The ball hits the cross bar at a point P a height H from the ground as shown in Figure 1.

(i) How much time does the ball spend in flight between the header and the cross bar? **(3 marks)**

(ii) What is the height of the cross bar from the ground? **(3 marks)**

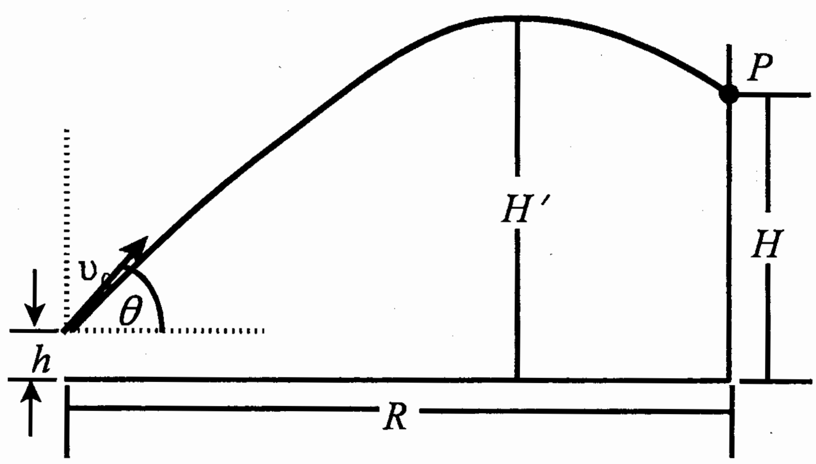

Figure 1.

QUESTION 2

(a) The two blocks in Figure 2 are connected by strings of negligible mass that pass over a frictionless pulley. The acceleration of the system is such that m_2 moves down the inclined plane while m_1 moves up the inclined plane. The coefficient of kinetic friction between all surfaces is 0.05.

(i) Make a free body diagram for each block. The forces must be resolved to appropriate coordinates so that useful equations can be obtained from the diagrams. **(4 marks)**
(ii) Write down the pair of equations for each block. **(4 marks)**
(iii) Find the acceleration of the system. **(4 marks)**

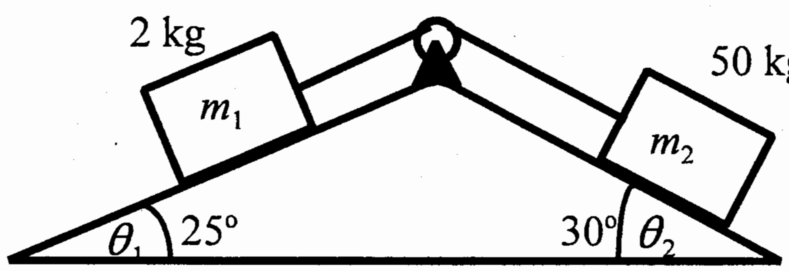

Figure 2.

(b) The system shown in Figure 3 is in equilibrium. The uniform beam is 14 m long and weighs 2000 N. The box on the beam has a mass of 300 kg and is 5 m from the wall.

(i) Determine the tension T and the mass m_3. **(7 marks)**
(ii) Find the x- and y- components of the reaction force due to the wall. **(3 marks)**
(iii) What angle ϕ does the reaction force due to the wall make with the horizontal? Illustrate the angle. **(3 marks)**

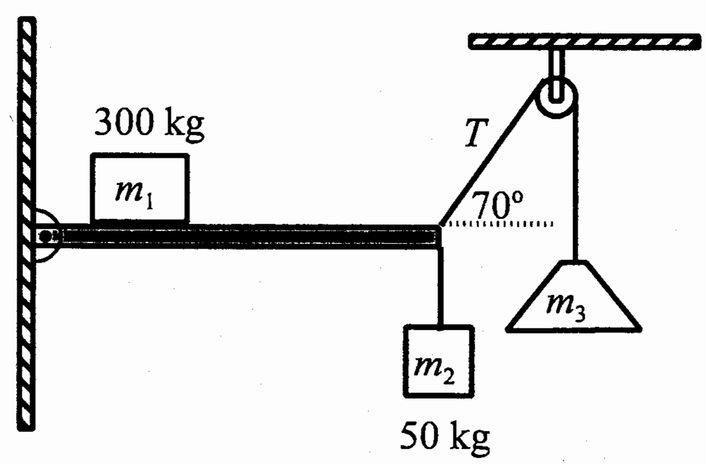

Figure 3.

QUESTION 3

(a) The system in Figure 4 is released from rest with the 50 kg block 8 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)**

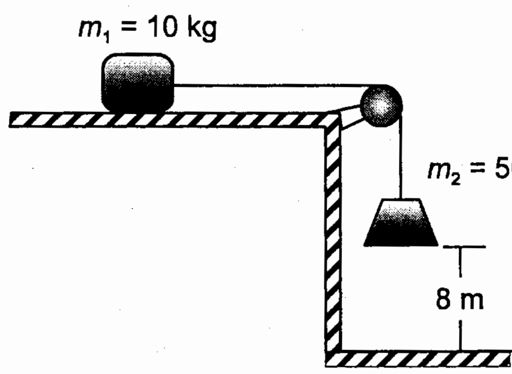

Figure 4.

(b) A 20 ton truck moving west at 90 km/hr collides at a junction of a slippery road with a 2 ton car moving north at 190 km/hr. Both drivers were not aware that they had to stop at the cross junction such that no one applied the brakes. After the collision both vehicles pile up into one wreckage.

(i) What angle does the velocity of the wreckage make with the original direction of the truck? **(7 marks)**

(ii) What was the velocity of the wreckage just after the collision? **(2 marks)**

(iii) What kind of a collision is this? **(2 marks)**

(c) A vehicle is idling at 900 rpm. Its accelerator is depressed, causing the angular velocity to rise to 5000 rpm in 0.5 min.

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

(ii) What angle does it turn through in the first 30 s? **(2 marks)**

(iii) What is the kinetic energy of the wheel at $t = 30$ s if its moment of inertia is 160 kg m^2? **(1 mark)**

QUESTION 4

(a) To deform a material, discuss what is more important between force and stress?**(2 marks)**

(b) Sketch a stress-strain diagram for a ductile metal, label all its parts, and discuss it. **(7 marks)**

(c) A block of wood has sides of length $a = 30$ cm, $b = 20$ cm and $c = 10$ cm and a density of 650 kg/m^3. It floats in sea water of density 1025 kg/m^3, with one of the faces with edges of length a and b facing upwards. What is the length of the block below the water? **(7 marks)**

(d) A large storage tank, open at the top and filled with water, develops a small hole in its side at a point 16 m below the water level. Determine the speed with which the water leaks from the hole. State all assumptions made. **(9 marks)**

QUESTION 5

(a) A copper telephone wire is 35 m long at -10 °C. How much longer is the wire on a day when the temperature reaches 35 °C? $\alpha = 17 \times 10^{-6}\ k^{-1}$. **(2 marks)**

(b) Discuss the processes by which heat energy is transferred from one region to another. **(6 marks)**

(c) Two kilograms of ice at -10 °C are mixed with 5 kg of water at 20 °C in a perfectly insulating container to make an ice bath. How much ice melts in the process? **(8 marks)**

(d)

(i) What is an ideal gas? **(2 marks)**

(ii) How many particles of a gas at a temperature of 25 °C fill a volume of 2 m^3 at 2 times the atmospheric pressure? **(3 marks)**

(iii) If the gas is heated and the pressure increases to 4 atmospheres while it expands to 3 m^3, what is the final temperature 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