UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN 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 two vectors $\vec{A} = -3\hat{i} - 4\hat{j} + 6\hat{k}$ and, $\vec{B} = 2\hat{i} - \hat{j} + 2\hat{k}$, find the angle between the vectors $\vec{A}$ and $\vec{B}$. **(5 marks)**

(b) A body with an initial velocity of 5 m/s is accelerated at 2 m/s^2 for 4 s. It then moves at constant velocity for 3 s after which it is accelerated at -4 m/s^2 for 5 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) An aircraft carries emergency supplies to an isolated refugee camp where there is no landing strip close by. The aircraft flies horizontally with a speed u_0 at an altitude h = 1 km from the ground. At a horizontal distance R = 1.5 km from the camp it releases the emergency supplies and they land right at the camp (See Figure 1). What is the velocity of the aircraft u_0? Neglect air resistance and wind. **(5 marks)**

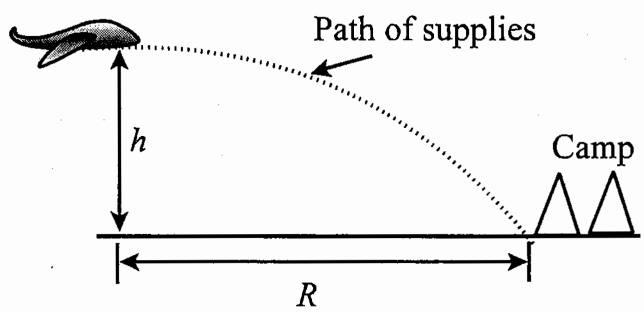


Figure 1.

QUESTION 2

(a) The system shown in Figure 2 is in equilibrium. Find the tension in each cord, and the mass m_2. **(9 marks)**

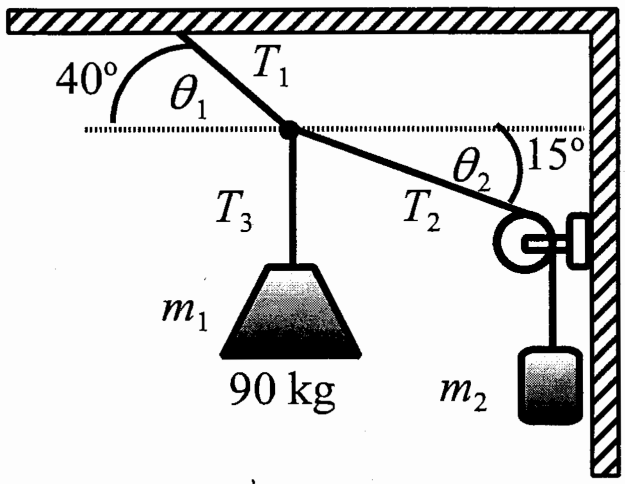


Figure 2.

(b) The three blocks in Figure 3 are connected by strings of negligible mass that pass over frictionless pulleys. The acceleration of the system is such that m_3 moves down the inclined plane, m_2 moves to the right and m_1 moves up the inclined plane. The acceleration of each mass is a = 2 m/s^2. The coefficient of friction is the same between all surfaces.

(i) Make a free body diagram for each body. The forces must be resolved to appropriate coordinates so that useful equations can be obtained from the diagrams. **(6 marks)**
(ii) Write down the pair of equations for each body. **(6 marks)**
(iii) Find the coefficient of kinetic friction between the bodies and the surfaces. **(4 marks)**

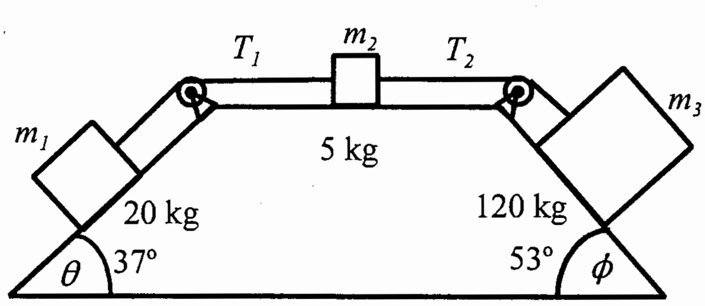


Figure 3.

QUESTION 3

(a) A block of mass 2 kg starts from rest at the top of an inclined plane and slides down to the bottom (See Figure 4). The coefficient of kinetic friction between the block and the surface is 0.2.

(i) What is the initial energy of the system? **(2 marks)**

(ii) What is the work lost due to friction after the block slides over the distance l? **(3 marks)**

(iii) What is the velocity of the block when it reaches the ground? **(3 marks)**

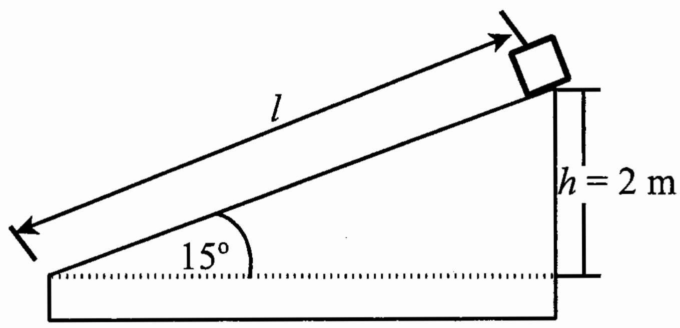


Figure 4.

(b) 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 a velocity $v_A = 40$ m/s and is deflected at an angle $\theta_A = 40°$ from its original direction with a speed V_A' as shown in Figure 5. Billiard ball *B* acquires a velocity v_B' at an angle $\theta_B = 30°$ with the original velocity of billiard ball *A*. Find the speed of each billiard ball after the collision.
(9 marks)

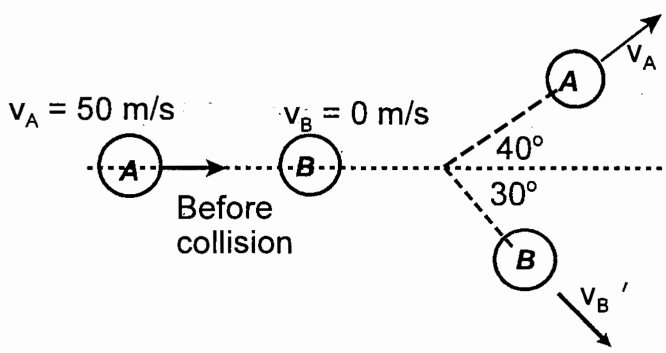


Figure 5.

(c) A flywheel of moment of inertia $I = 65$ kg m^2 which is initially at rest experiences a torque of 10 Nm.

(i) What is the angular acceleration of the wheel? **(2 marks)**

(ii) What is the angular velocity of the wheel at $t = 5$ s? **(2 marks)**

(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? **(2 marks)**

QUESTION 4

(a) A steel wire has the following properties:

length = 5 m
cross section = 0.05 cm^2.
Young's modulus = 1.8×10^{11} Pa
Proportional limit = 3.6×10^{8} Pa
Breaking stress = 7.2×10^{8} Pa

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

(i) What is the mass if the wire stretches to the proportional limit? **(3 marks)**
(ii) How much does the wire stretch at the proportional limit? **(3 marks)**

(b) Sketch a stress strain diagram for vulcanised rubber materials and give an explanation of the graph and an example where such materials are used. **(7 marks)**

(c) The liquid in the open tube manometer shown in Figure 6 is mercury y_1 = 5 cm and y_2 = 15 cm. What is the gauge pressure of the gas in the tank? **(6 marks)**

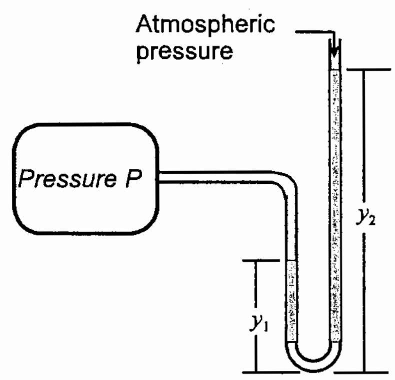
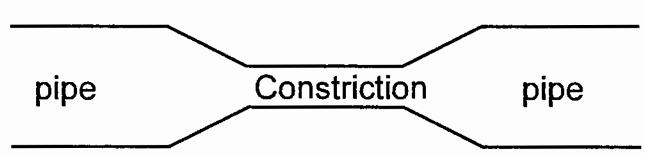


Figure 6.

(d) A broken water pipe is mended in an unprofessional way leading to a constriction where it is mended. The pipe has a cross-sectional area of 7 cm^2 while the constriction has a cross-sectional area of 3 cm^2. The velocity of the water in the main pipe is 2 m/s.

(i) Find the velocity of the water at the mended part of the pipe? **(2 marks)**
(ii) What is the pressure of the water at the constricted part? **(4 marks)**

Figure 7.



QUESTION 5

(a) A metall ball of mass 80 g at 100°C is placed into a perfectly insulating container with 100 g of ice at minus 5°C. All the ice melts and the final temperature of the water and metal ball is 30°C. What is the specific heat capacity of the metal? **(8 marks)**

(b) How does a thermoflask minimise heat transfer between its contents and surroundings? **(7 marks)**

(c) Why does a beverage container break when kept too long in a freeser?**(5 marks)**

(d) A tank is used to store three moles of an ideal gas at a pressure of 2 atmospheres and a temperature of 20°C. Under internal pressure, the tank can burst if the pressure reaches 6 atmospheres. The material from which the tank is made has a melting point of 1300°C. Determine whether this process is possible. Hint, find the temperature at which the pressure rises to 2.5 atmospheres. **(5 marks)**

GENERAL DATA SHEET

Speed of light in vacuum c = 2.9978 x 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 x 10^{-11} N m^2/kg^2
Density of mercury = 1.36 x 10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013 x 10^5 Pa
Gas constant R = 8.314 J/(K mol)
Avogadro's number N_A = 6.022 x 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 x 10^3 J

c(*water*) = 4186 J/(kg K)   c(*ice*) = 2090 J/(kg K)   c(*steam*) = 2079 J/(kg K)
L_f(*ice*) = 3.33x10^5 J/kg L_v(*water*) = 2.260x10^6 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 x 10^{-19} C
Charge of a proton = +1.6 x 10^{-19} C
1 atomic mass unit = 1 amu = 1 u = 1.66 x 10^{-27} kg
Electron mass, m_e = 9.109 x 10^{-31} kg
Proton mass, m_p = 1.673 x 10^{-27} kg
Neutron mass m_n = 1.675 x 10^{-27} kg