UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2008/09

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 $\vec{B} = 2\hat{i} - 2\hat{j} + 2\hat{k}$, find

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

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

(b) With the aid of a diagram show what you understand by the dot product of two vectors $\vec{A}$ and $\vec{B}$ separated by an angle θ. **(3 marks)**

(c) A body moves along the x-axis according to the velocity-time graph shown in Figure 1. The accelerations $a_{0,4}$, $a_{4,7}$ and $a_{7,11}$ are 4, 0, and -6 m/s^2, respectively. Calculate the distance travelled at appropriate points and sketch the distance-time graph. Let $x_0 = 0$ m. **(6 marks)**

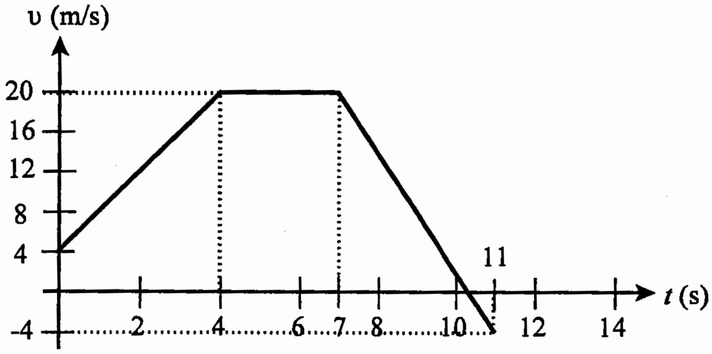

Figure 1.

(d) A basketball player standing on the floor 10 m from the basket hoop shoots a basketball from a height of 2 m, (see Figure 2). The initial velocity of the ball is $\upsilon_0 = 10.7$ m/s and leaves the hands of the player at an angle $\theta = 40°$ with the horizontal.

(i) How much time does the basketball take to move from the player to the basket hoop? **(3 marks)**

(ii) What is the height h of the hoop from the ground? **(4 marks)**

(iii) Determine the y-component of the velocity of the ball when it enters the basket. **(2 marks)**

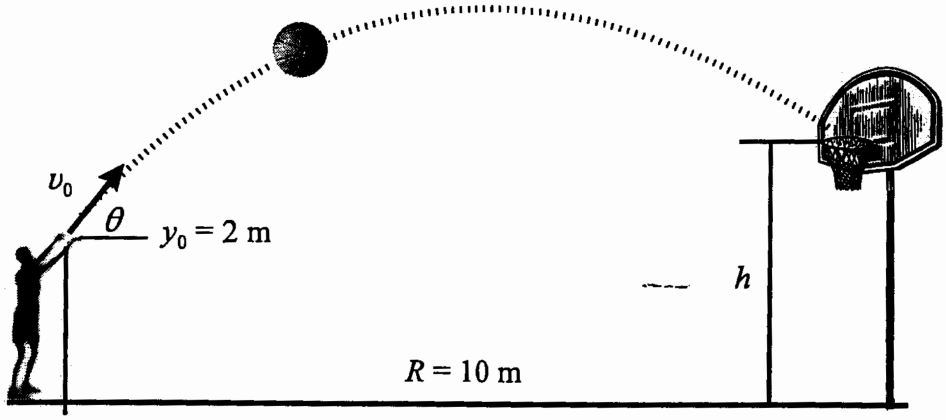

Figure 2.

QUESTION 2

(a) The system shown in Figure 3 is in equilibrium. Determine the tension in each string and the mass m_2. The pulley is frictionless. **(10 marks)**

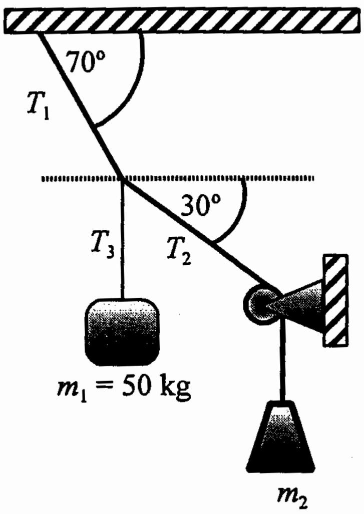

Figure 3.

(b) The system shown in Figure 4 moves such that m_1 moves down the inclined plane and m_2 moves up the inclined plane. Neglect the masses of the strings and assume the pulley is frictionless. The coefficient of friction between all surfaces is 0.1.

(i) Make a resolved force diagram for each body from which useful equations of motion can be obtained. **(4 marks)**

(ii) Write down the equations of motion for each body. **(6 marks)**

(iii) Determine the acceleration of the system. **(5 marks)**

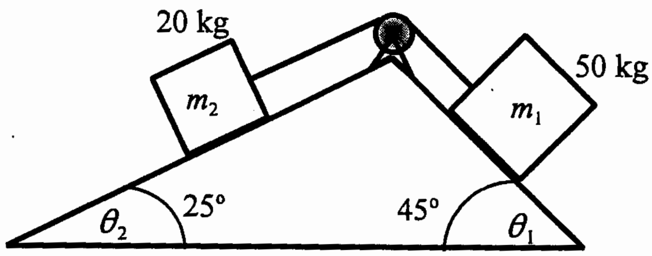

Figure 4.

QUESTION 3

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

(i) its maximum height, and **(5 marks)**

(ii) its velocity at a height of 15 m. **(5 marks)**

(b) Consider a body being pulled by a force $\vec{F}$, making an angle θ with the displacement $\vec{r}$. Write an expression for the work done W in terms of F, r and θ, and state what it means in words. **(2 marks)**

(c) At a construction site, a conveyor belt lifts a concrete mixture at a rate of 40 kg per minute over a height of 10 m. The concrete mixture moves on the conveyor belt at a speed of 0.5 m/s.

(i) How much potential energy is given to the mixture per minute? **(2 marks)**

(ii) How much kinetic energy is given to the mixture per minute? **(2 marks)**

(iii) What is the power of the conveyor motor? **(2 marks)**

(d) A rifle bullet of mass $m = 150$ g moving at a velocity $\upsilon_0 = 400$ m/s along the x-axis strikes a stationary block of mass $M = 2$ kg which rests on a horizontal frictionless surface. After impact the block acquires a velocity $V' = 10$ m/s in the same direction as the original velocity of the bullet. Determine the velocity of the bullet, υ' after the collision. **(7 marks)**

QUESTION 4

(a) An acrobat of mass 80 kg rotates in a merry-go-round at a radius of 3 m from the axis of rotation with an angular velocity of 50 rpm.

(i) What is the moment of inertia of the acrobat about the axis of rotation? **(2 marks)**

(ii) What is the centripetal force on the acrobat at $\omega = 50$ rpm? **(3 marks)**

(iii) If the combined moment of inertia of the person and the merry-go-round is 2500 kg·m^2, what torque would be required to rotate the merry-go-round and the acrobat from an angular velocity of 0 to 50 rpm in 20 seconds? **(3 marks)**

(b) A disc with a moment of inertia $I_1 = 125$ kg.m^2 rotating with angular velocity $\omega_0 = 300$ rad/s is brought in contact with a stationary disk of moment of inertia $I_2 = 200$ kg.m^2 such that their axis of rotation coincide. What is the final angular velocity, ω' reached by the two discs? **(6 marks)**

(c) Discuss with the aid of a diagram the stress versus strain graph for materials with a hysterisis loop like some rubber materials. Give an example of the use of such materials. **(7 marks)**

(d) Discuss what is more important to consider as responsible for the permanent deformation of a material between force and stress. Give an example to illustrate your answer. **(4 marks)**

QUESTION 5

(a) 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? Show fully how you obtain the final equation used. **(5 marks)**

(b) State Pascal's Law and give an example of its application in daily life. **(4 marks)**

(c) A block of wood has sides of length $a = 40$ cm, $b = 50$ cm and $c = 60$ cm, and a density of 685 kg/m^3. It floats in sea water of density 1025 kg/m^3, with one of the faces with edges of lengths a and b facing upwards. What is the height of the top surface of the block above the water? **(7 marks)**

(d) A sealed tank contains water for a fire hydrant to a level of 20 m. Above the water level there is pressurised air at a pressure of 5 atmospheres. The 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 initially comes out of the tank. State all assumptions made. **(9 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}
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J
Specific heat capacity for water $c_w = 4186$ J/(kg K)
Specific heat capacity for ice $c_i = 2090$ J/(kg K)
Specific heat capacity for steam $c_s = 2079$ J/(kg K)
Latent heat of fusion for ice $L_f = 3.33 \times 10^5$ J/kg
Latent heat of vapourisation for water $L_v = 2.260 \times 10^6$ J/kg
Coulomb's constant $k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \, Nm^2/C^2$
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