UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2012/2013

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 $\vec{A} = 4\hat{\imath} - 3\hat{\jmath} + 5\hat{k}$ and $\vec{B} = -2\hat{\imath} + 4\hat{\jmath} - 3\hat{k}$, find

(i) the angle between the two vectors, and **(7 marks)**

(ii) the cross products of the two vectors $\vec{C} = \vec{A} \times \vec{B}$. **(4 marks)**

(b) A negligent camper parks his vehicle with faulty parking brakes in neutral on a steep incline a certain distance from the edge of a cliff 50 m high. The incline makes an angle of 37° with the horizontal. (See Figure 1). The vehicle starts moving on its own from rest and reaches a velocity of 8 m/s, when it reaches the edge of the cliff.

(i) What are the x- and y-components of the velocity of the vehicle at edge of the cliff? **(2 marks)**

(ii) What is the y-component of the velocity of the vehicle when it hits the bottom of the cliff? **(4 marks)**

(iii) Find the x-component of the velocity of the vehicle when it hits the bottom of the cliff. **(2 marks)**

(iv) How much time does the vehicle take to move from the edge of the cliff to the landing point at the bottom of the cliff? **(2 marks)**

(v) How far from the cliff does the vehicle land? **(2 marks)**

(vi) What is the angle the velocity of the vehicle makes when it hits the bottom of the cliff? Also illustrate the angle. **(2 marks)**

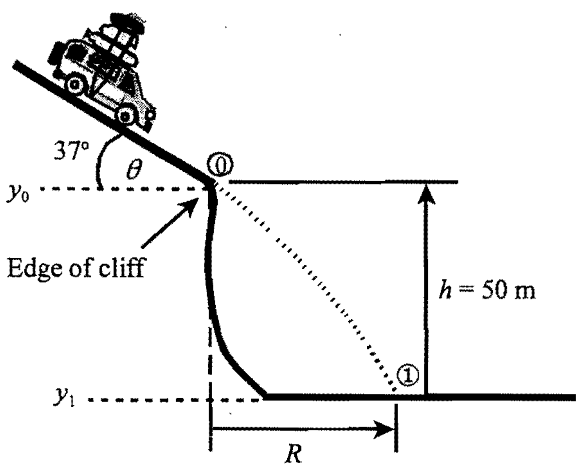

Figure 1.

QUESTION 2

(a) Three masses are connected by inextensible cords as shown in Figure 2. A force F is applied to m_3 causing the system to move such that m_1 and m_3 move towards the right while m_2 moves up the inclined plane. All bodies move at constant velocity. The coefficient of kinetic friction between all surfaces in contact is 0.6. The pulleys have negligible mass and are frictionless. The masses of the cords can be neglected.

(i) Study the system carefully and make resolved force diagrams for each mass. **(6 marks)**

(ii) Write down the force equations for each mass. **(6 marks)**

(iii) Find the applied force F. **(6 marks)**

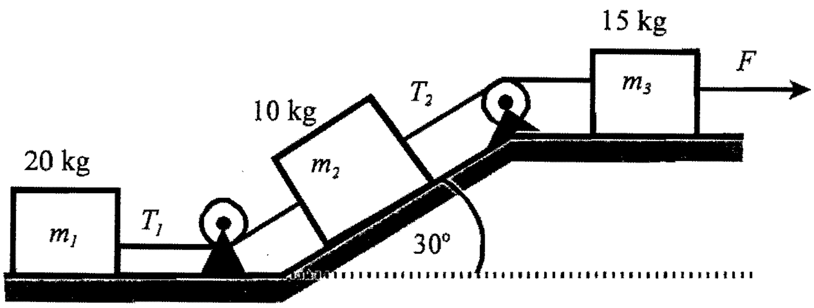

Figure 2.

(b) The system shown in Figure 3 is in equilibrium. The platform is uniform, 10 m long, and has a weight $W = 2000$ N. The cord is attached at the centre of the platform and makes an angle $\theta = 50°$ with the horizontal. The boxes of supplies are centred 3 m from the wall and have a total mass $m_s = 225$ kg. The person of $m_p = 72$ kg stands a distance of 8 m from the wall. Determine the tension in the cord. **(7 marks)**

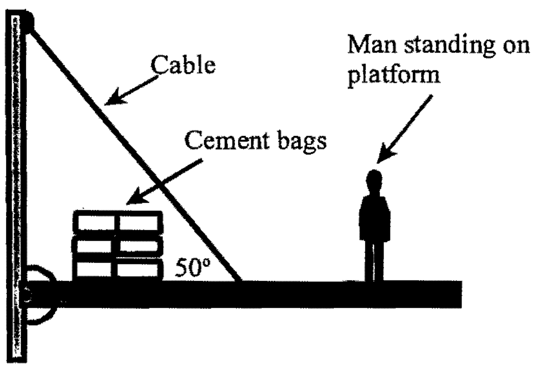

Figure 3.

QUESTION 3

(a) A rifle bullet of mass $m = 200$ g strikes and embeds itself in a block of mass $M = 4$ kg which rests on a horizontal frictionless surface and is attached to a coil spring of spring constant $k = 5000$ N/m, as shown in Figure 3. The impact force of the block compresses the spring by $A = 5$ cm.

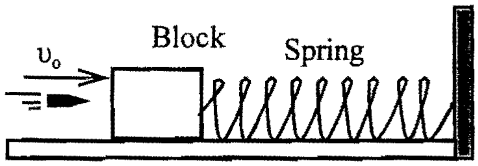

Figure 3.

(i) Find the velocity of the bullet and the block just after the impact? Assuming the collision is very fast. **(4 marks)**

(ii) What was the original velocity of the bullet υ_0? **(4 marks)**

(b) Billiard ball A originally traveling at velocity $\upsilon_0 = 4$ m/s along the x-axis strikes a stationary billiard ball B of the same mass m resting on a frictionless table. After the collision billiard ball A is deflected with a velocity $\upsilon_A{}'$ at an angle $\theta_A = 30°$ from its original direction, whole billiard ball B acquires a velocity $\upsilon_B{}'$ at an angle $\theta_{B=} = 50°$ with original direction of billiard ball A. Determine the velocities $\upsilon_A{}'$ and υ_B' of the two billiard balls after the collision. The situation is illustrated in Figure 4. **(12 marks)**

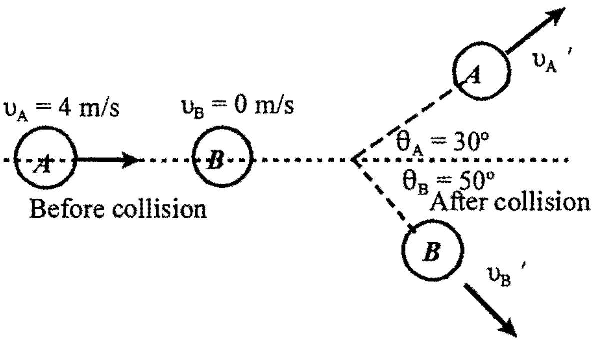

Figure 4.

(c) An engine flywheel is uniformly accelerated from 600 rpm to 7500 rpm in 4 s. Find its angular acceleration. **(5 marks)**

QUESTION 4

(a) Make a stress-strain diagram for a ductile metal and label all its parts. **(5 marks)**

(b) A solid platform of area $A = 4\ \text{m}^2$ and density $\rho_p = 650\ \text{kg/m}^3$ is to be used to support a load of mass m_l = 850 kg on fresh water. Determine the thickness t of the platform to just support the load above the water. **(7 marks)**

(c) State Pascal's law and give two examples of its application in everyday life, explaining in each case how this law is applied. **(6 marks)**

(d) A sealed tank contains water for a fire hydrant to a level $h = 15$ m. Above the water level there is pressurised air at a pressure of 7.5 atmospheres. A small hole develops at the bottom of the tank. Use Bernoulli's equation to determine the velocity at which the water comes out at the bottom of the tank. State all assumptions made. **(7 marks)**

QUESTION 5

(a) In an experiment to determine the thermal coefficient of linear expansion of a material, the material is made into a uniform rod and measured to have a length of exactly $l_0 = 50.00$ cm at 0°C. The rod is then heated to 150°C, and its length measured to be $l = 50.45$ cm. Determine the thermal coefficient of expansion α for this material. **(3 marks)**

(b) Steam of mass $m_s = 5$ kg at a temperature of $T_s = 120$°C is bubbled into water of mass $m_w = 20$ kg at a temperature $T_w = 20$°C in an insulated container. Determine the final temperature of the system T_f. **(8 marks)**

(c) How does a Dewar flask prevent heat transfer between it contents and the surroundings? **(6 marks)**

(d) A hollow cube 25 cm on each edge contains nitrogen with an equivalent molar mass of 28.02 g/mol at atmospheric pressure and a temperature of 20°C.

- (i) Find the weight of the gas. State any assumptions made. **(3 marks)**
- (ii) What is the force the gas exerts on each face of the cube? **(2 marks)**
- (iii) Explain why such a small amount of gas can exert such a great force. **(3 marks)**

DATA SHEET

General data

Air refractive index = 1.00
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Density of mercury = 1.36×10^4 kg/m^3
Gas constant $R = 8.314$ J/(mol.K)
Gravitational acceleration $g = 9.80$ m/s^2
Refractive index of air $n_{air} = 1.000$
Standard atmospheric pressure = 1.013×10^5 Pa
Speed of light in vacuum $c = 2.997\,8 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ $W/(m^2.K^4)$
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ $N.\ m^2/kg^2$
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

Water data

$c(water) = 4186$ J/(kg.K)	$c(ice) = 2090$ J/(kg.K)	$c(steam) = 2079$ J/(kg.K)
$L_f(ice) = 3.33\text{x}10^5$ J/kg	$L_v(water) = 2.260\text{x}10^6$ J/kg	
ρ (water) = 1000 kg/m^3	refractive index $n_w = 1.333$	

Electricity and nuclear data

Alpha particle mass = $6.644\,657 \times 10^{-27}$ kg
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
Coulomb's constant $k_e = 8.987\,5 \times 10^9$ Nm^2/C^2
Deuteron mass = $3.343\,583 \times 10^{-27}$ kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
$\epsilon_0 = 8.85 \times 10^{-12}$ $C^2(N.m^2)$
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s