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UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS AND ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION 2005

TITLE O F PAPER:	INTRODUCTORY PHYSICS
COURSE NUMBER:	P100
TIME ALLOWED:	THREE HOURS
INSTRUCTIONS:	ANSWER ANY FOUR OUT OF SIX 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 EIGHT 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) A body moving in the positive *x*-axis direction starts at 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)**

(b) An aircraft moves horizontally above ground with a velocity of 50 m/s at an altitude of 10 km. One of its engines breaks off and falls towards the ground under gravity.

- (i) What is the *y*-component of the velocity of the engine when it hits the ground? **(3 marks)**
- (ii) How much time the engine spend in the air? **(3 marks)**
- (iii) What is the range of the engine? **(2 marks)**
- (iv) What angle does the velocity of the engine make with the horizontal when it lands? **(2 marks)**

QUESTION 2

(a) The system shown in Figure 1. Is in equilibrium. Find the tension in each cord, and the mass m_2. **(9 marks)**

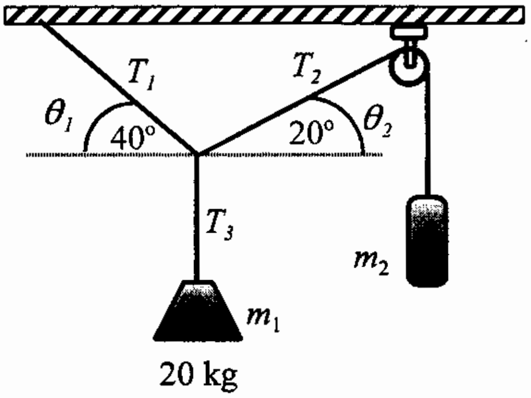

Figure 1.

(b)The system shown in Figure 2 is in equilibrium. The beam is uniform, of length L = 7 metres, and has a weight W = 500 N. The bags of cement are 2 m from the wall and have a mass M_c = 600 kg. The man who has a mass m_p = 90 kg stands 5 m from the wall. The cable is attached at the other end of the beam from the wall and makes and angle of 70° with the horizontal. Determine

(i) the tension in the cord, **(9 marks)**

(ii) the x- and y-components of the reaction force by the wall, and **(4 marks)**

(iii) the angle ϕ the reaction force makes with the horizontal and Illustrate the angle. **(3 marks)**

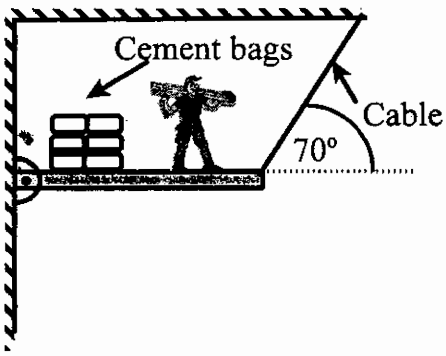

Figure 2.

QUESTION 3

(a) A body is given an initial downward velocity of 5 m/s from a height of 50 m from the ground. Use energy methods to find the velocity with which the body hits the ground. Include a diagram to show how you obtain your solution. **(5 marks)**

(b) A bullet of mass m = 100 g moving with an initial speed υ_0 = 400 m/s strikes and embeds itself in a stationary block of mass M = 5 kg resting on a horizontal frictionless surface. The block is attached to a spring of spring constant k = 100 N/m. The block and bullet compress the spring a maximum distance L = 10 cm after the impact.

(i) What is the velocity of the block and bullet υ_f just after impact? **(5 marks)**

(ii) How much energy is lost during impact? **(3 marks)**

(c) A bullet of mass m = 50 g moving with an initial speed υ_0 = 400 m/s strikes a stationary wooden block of mass M = 2 kg. The final velocity of the block is υ_f. The block acquires a velocity V' 1.25 m/s after the impact. What is the final velocity of the bullet υ_f? Also state whether the bullet goes through the block, imbedded in the block or bounces back. **(7 marks)**

(d) A child of mass 20 kg rotates in a merry-go-round at a radius of 4 m from the centre with an angular velocity of 33 rpm.

(i) What is the centripetal force on the child? **(3 marks)**

(ii) What is the moment of inertia of the child about the axis of rotation? **(2 marks)**

QUESTION 4

(a) A circular wire of length 2 m suspends a mass *m*. It stretches by 1.5 mm under a load. The wire has a Young's modulus of 6.5×10^{10} Pa.

(i) What is the strain on the wire? **(2 marks)**

(ii) What is the stress on the wire? **(2 marks)**

(iii) If the wire has a cross-sectional area of 5×10^{-5} m^2, what is the suspended mass *m*? **(2 marks)**

(b) State Pascal's laws and give an example where it is applied in everyday life. **(3 marks)**

(c) A sealed tank for fire hydrant contains water to a height of 10 m above ground. Above the water in the tank, there is pressurised air at a pressure of 3 atmospheres. The hose-pipe from the tank accidentally breaks off from the bottom of the tank. Starting with Bernoulli's equation, determine the velocity with which the water comes out at the developed hole. State all assumptions made. **(8 marks)**

(d) A block of ice of mass m_i = 50 g at a temperature of -5° C is dropped into 250 ml of water at a temperature of 20° C, in a copper calorimeter of mass 50 g. Neglecting heat losses to the surroundings, what is the final temperature reached? **(8 marks)**

QUESTION 5

(a) A light ray starts from water (n = 1.33) towards an oil layer (n = 1.6) above it, towards air. The angle of incidence at the water-oil interface is 20°. Determine the angles of refraction at the water-oil interface and oil-air interface. **(6 marks)**

(b) Show with the aid of diagrams how real and virtual images can be formed by a converging lens. **(6 marks)**

(c) The far point of a person is 30 m. The person wants to be able to watch sports and would like his far point to be stretched to 1 km. What should be the focal length of the spectacle lenses? **(4 marks)**

(d) Three charges are arranged such that q_1 = 4 μC is at y = 20 cm, and q_2 = -6 μC is at x = 20 cm. See Figure 4.

(i) What are the x- and y-components of the electric field at the origin, also include their directions? **(4 marks)**

(ii) What is the magnitude of the electric field. **(2 marks)**

(iii) What angle does the electric field make with the origin? Illustrate the angle. **(3 marks)**

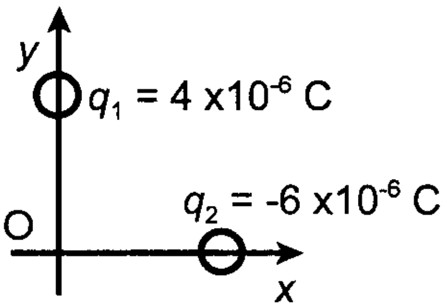

Figure 3.

QUESTION 6

(a) State what an *emf* source is and give an example. **(2 marks)**

(b) A capacitor of capacitance $C = 50\ \mu F$ is charged through a resistor $R = 4.7\ k\Omega$ by a 12 V battery.

(i) Write down the general equations for charging and discharging a capacitor and include sketches of the associated graphs. **(6 marks)**

(ii) What is the time-constant τ for the circuit described in this problem. **(2 marks)**

(iii) Find the values of charge after one time constant for both charging and discharging the capacitor in this problem. **(5 marks)**

(v) When fully charged, what is the energy stored in the capacitor? **(2 marks)**

(c) State the two Kirchoff's laws that can enable you to determine currents and voltages in a network. **(2 marks)**

(d) The rectangular wire loop shown in Figure 4 carries a current *I* in the anticlockwise direction. It is placed in a magnetic field ***B*** in the negative *y*-direction. Use the cross product to determine how the wire will move if it will move at all. **(6 marks)**

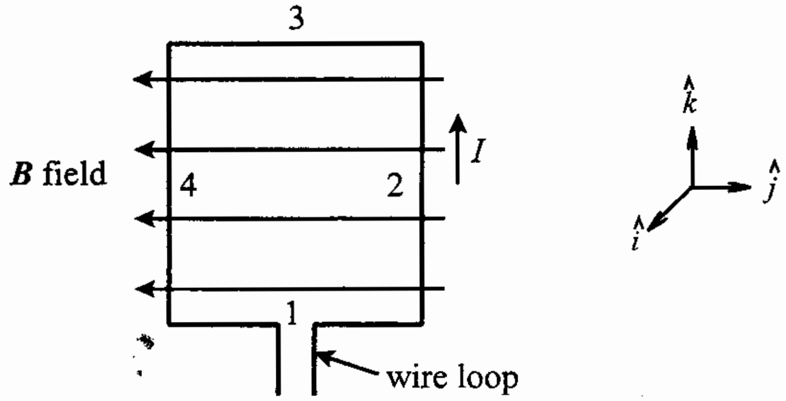

Figure 4.

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 = 6.67×10^{-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)
$L_f(ice) = 3.33\times10^5$ J/kg
$L_v(water) = 2.260\times10^6$ J/kg
c(copper) = 387 J/(kg K)

$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ Nm^2/C^2

Charge of an electron $e = -1.6 \times 10^{-19}$ 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