UNIVERSITY OF SWAZILAND
FACULTY OF HEALTH SCIENCES

DEPARTMENT OF ENVIRONMENTAL SCIENCE

MAIN EXAMINATION 2009/10

TITTLE OF PAPER: PHYSICS FOR HEALTH SCIENCES

COURSE NUMBER: HSC107

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. ANSWER QUESTION 1
2. ANSWER ANY FOUR QUESTIONS FROM 2 TO 6
3. EACH QUESTION CARRIES 20 MARKS
4. MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN
5. 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

COMPULSORY QUESTION

QUESTION 1

(a) Explain whether a body moving around a curve at constant speed has an acceleration. **(4 marks)**

(b) From your understanding of momentum, explain how air bags in vehicles help reduce injuries during collisions. Include a relevant equation. **(4 marks)**

(c) Why do ships that are made of steel which has a higher density than sea water float? Include relevant equations in your discussion. **(4 marks)**

(d) Explain why beverage containers break when put in a freezer for too long. **(4 marks)**

(e) A person with a wet skin (R = 1000 Ω) standing on a wet floor touches an exposed 230 V live wire household power line. Find the current through the person and state whether or not this current would be harmful to the person. **(4 marks)**

CHOOSE ANY FOUR QUESTIONS FROM QUESTION 2 TO 6

QUESTION 2.

(a) Given two vectors $\vec{A}$ and $\vec{B}$ explain what you understand by the dot product $\vec{A} \bullet \vec{B}$ of the two vectors. **(2 marks)**

(b) A body initially moving at 2 m/s accelerates to 18 m/s in 4 s, and then moves at constant velocity for 5 s after which it accelerates to a velocity of -2 m/s in 5 s. The accelerations are as follows: $a_{0,4} = 4$ m/s^2, $a_{4,9} = 0$ m/s^2, and $a_{9,14} = -4$ m/s^2. Sketch

(i) the velocity-time graph and **(5 marks)**

(ii) the distance-time graph for this motion. **(7 marks)**

(c) The system shown in Figure 1 is a traction to assist in the healing of a broken lower leg.

(i) Explain where each mass helps in the healing process. **(2 marks)**

(ii) What is m_1 if the force to be provided by this mass is 15 N? **(2 marks)**

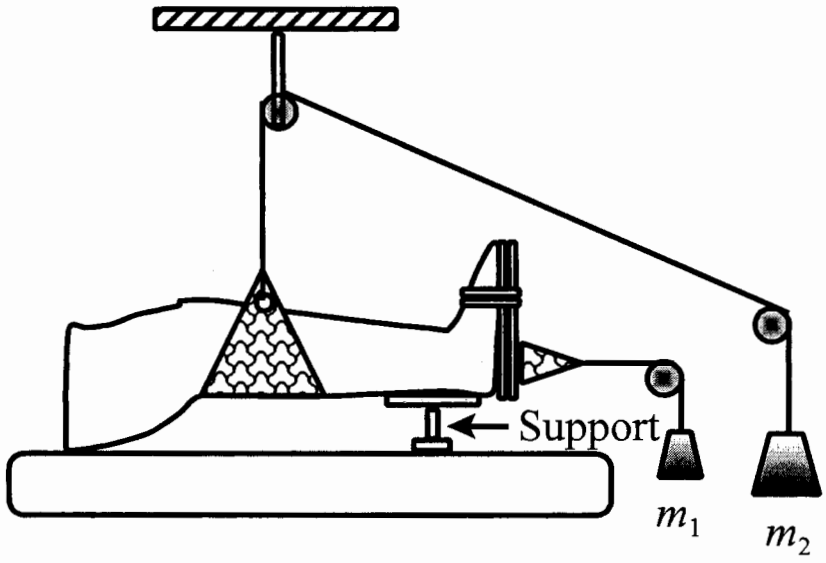

Figure 1.

QUESTION 3

(a) A household uses 4 indoor incandescent lamps rated at 60 W, and operates for 4 hours a day. In addition they use 3 outdoor security incandescent lamps rated at 75 W each which are kept on for 8 hours a day. electricity costs 60 cents per kilowatt-hour.

(i) Determine the annual cost of lighting for the household. **(4 marks)**

(ii) If the household changes to compact flourescent lamps (CFLs) rated at 15 W for indoor lighting and 25 W for the security lights, how much money would they save per year in electricity cost? **(4 marks)**

(iii) State an concern that you may have about the CFLs. **(2 marks)**

(b) Use your understanding of momentum to explain why a gun moves backwards (recoil) when it fires a bullet. **(4 marks)**

(c) How does a centrifuge separate particles of varying density? Use relevant equations in you explanation. **(6 marks)**

QUESTION 4

(a) Assume that Young's modulus is 1.5×10^{-10} N/m^2 for the human bone, and that the bone will fracture if stress greater than 1.50×10^{-8} N/m^2 is imposed on it.

(i) What is the maximum force that can be exerted on the femur bone in the leg if it has an effective diameter of 2.5 cm? **(4 marks)**

(ii) If this force is applied compressively, by how much does the 25 cm long bone shorten? **(3 marks)**

(b) The pressure of the cerebrospinal fluid (the fluid in which the human brain and spinal cord are immersed in) can be measured by means of a spinal tap, where a hollow tube is inserted in the spinal column, held vertically and the height to which the fluid rise is observed. If the fluid rises to a gauge pressure of 160 mm of H_2O, determine this pressure

(i) in pascal and **(2 marks)**

(ii) mm of mercury. **(2 marks)**

(c) In an insulated vessel, 250 g of ice at 0°C is added to 600 g of water at 18°C.

(i) Show by finding the heat required to melt all the ice and the heat required to cool the water to 0°C that only part of the ice melts, leaving an ice bath of water and ice. **(5 marks)**

(ii) How much ice remains when the system reaches equilibrium? **(4 marks)**

QUESTION 5

(a) A sound wave traveling through air produces pressure variations given by

$$P = 2.52 \sin(\frac{1}{2}x - 340\pi t) \text{ Pa.}$$

(i) What is the amplitude of the disturbance? **(2 marks)**
(ii) What is the frequency of the wave? **(2 marks)**
(iii) Find the wavelength of the wave. **(2 marks)**
(iv) Find the speed of the wave. **(2 marks)**

(b) The power output of a certain public address system is 60 W. Assume that it broadcast equally in all directions. Find the intensity at the threshold of pain (120 dB) and determine the distance from the speaker within which the sound would be painful to the human ear?**(6 marks)**

(c) A thin lens has a focal length of 25 cm. Locate and describe the image when the object is placed 26 cm and 24 cm in front of the lens. **(6 marks)**

QUESTION 6

(a) An incandescent lightbulb is rated at 75 W when attached to a 230 V rms wall socket.

(i) Under ideal conditions, what is the total current delivered to the bulb? **(2 marks)**

(ii) What is the resistance of the light bulb? **(2 marks)**

Now suppose that the two cords connecting the light bulb to the wall socket each has a resistance of 0.8 Ω

(iii) Draw a circuit diagram that illustrate this arrangement. **(2 marks)**

(iv) What is now the current from the wall socket? **(2 marks)**

(v) What is now the voltage across the bulb? **(2 marks)**

(vi) What is the power delivered to the light bulb? **(2 marks)**

(b) State any two effects that an electric shock can cause to a human body. **(4 marks)**

(c) A step down transformer is to be used to reduce the voltage from the 230 V rms wall socket voltage to 8 V rms in order to charge a cell phone battery. The transformer draws 350 mA from the wall socket.

(i) What are the turns ratio in the transformer of the power supply? **(2 marks)**

(ii) What is the secondary current? **(2 marks)**

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 343 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 (Hg) = 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

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

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

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