UNIVERSITY OF SWAZILAND
FACULTY OF HEALTH SCIENCES

DEPARTMENT OF ENVIRONMENTAL SCIENCE

MAIN EXAMINATION 2010/11

TITTLE OF PAPER: PHYSICS FOR HEALTH SCIENCES

COURSE NUMBER: HSC107

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. ANSWER ANY FOUR QUESTIONS
2. EACH QUESTION CARRIES 25 MARKS
3. MARKS FOR EACH SECTION ARE INDICATED AT THE RIGHT HAND MARGIN
4. 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 GRANTED BY THE CHIEF INVIGILATOR

QUESTION 1

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

(b) A body starts at the origin with a velocity of 5 m/s and accelerates to 21 m/s in 4 s, and then moves at constant velocity for 4 s after which it accelerates to -3 m/s (minus 3 m/s) in 6 s.

(i) Sketch the velocity-time graph. **(5 marks)**

(ii) Determine the accelerations $a_{0,4}$, $a_{4,8}$, and $a_{8,14}$ where the subscripts refer to the time intervals in seconds. **(3 marks)**

(iii) Sketch the distance-time graphs for this motion. **(7 marks)**

(c) A body is projected vertically with a velocity of 20 m/s. Use kinematics to determine its velocity at a height of 15 m, and comment on the solution obtained. **(4 marks)**

QUESTION 2.

(a) Shown in Figure 1 is a balanced suspension traction with slings and skeletal traction applied to the femur of an injured leg. The cords providing the tensions T_1 and T_3 make angles $\theta_1 = 30°$ and $\theta_3 = 70°$, respectively, and T_2 is vertical. Neglect the weight of the leg. The reaction force by the hip joint is F.

(i) Determine the tensions T_1, T_2 and T_3. **(3 marks)**

(ii) Make a resolved free-body diagram of the traction forces on the leg. **(4 marks)**

(iii) Find the x- and y-components (F_x and F_y) of the reaction force by the hip joint. **(4 marks)**

(iv) Use one of Newton's laws to determine the x- and y-components of the force applied by the traction system. **(3 marks)**

(v) From the results in (iv) determine the magnitude of the force F_T applied by the traction, and the angle ϕ the force due to the traction make with the horizontal. Also illustrate the force and the angle? **(3 marks)**

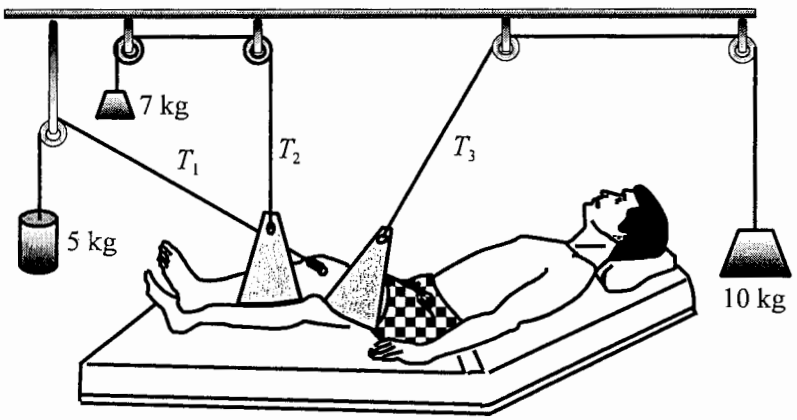

Figure 1.

(b) In an effort to loose body fat a student of mass 55 kg who takes HSC107 runs up and down some steps at a stadium and gains a height of 12 m each time he reaches the top. Assume that the calorific value of body fat is 9 food calories per gram.

(i) Find the work done by the student to rise from the bottom of the steps to the top in joules and in food calories. **(2 marks)**

(ii) How much energy in food calories is contained in 1 kg of body fat? **(2 marks)**

(iii) How many times must the student run up and down the steps to loose 1 kg of body fat if the energy to come down is neglected? **(2 marks)**

QUESTION 3

(a) A swimmer of mass $m = 60$ kg rests on a Styrofoam slab of thickness $t = 5$ cm and density $\rho_s = 450$ kg/m^3 in fresh water. The slab floats with its top surface at the same level as the water surface. Find the area of the slab. **(6 marks)**

(b) A medicine has to be administered patient to a person with a systolic/diastolic pressures of 140/90, using a hypodermic syringe with a medicine that has the same density as water. The barrel of the syringe has a cross-sectional area $A = 2.5 \times 10^{-5}$ m^2, and the needle has a cross-sectional area $a = 1 \times 10^{-8}$ m^2. (See Figure 2.) A force of 2 N is used on the plunger to push the medicine.

(i) What is the pressure applied to the medicine in the syringe? **(2 marks)**

(ii) How is the square of velocity of the medicine inside the barrel related to the square of the velocity of the medicine inside needle? **(3 marks)**

(iii) What is the systolic pressure of the blood in the vein in Pascal? **(2 marks)**

(iv) With what velocity does the medicine enter the blood vein? **(7 marks)**

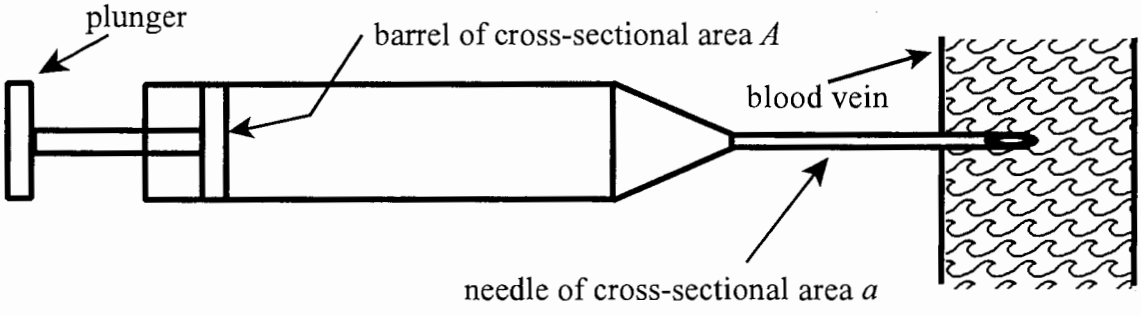

Figure 2.

(c) A HSC107 student of mass 58 kg has a fever and his body temperature is $T = 38.5$°C. In an effort by the body to reduce its temperature the student sweats water which has a latent heat of vaporization $L_v = 2.26 \times 10^6$ J/kg at this temperature. The specific heat capacity of the human body is 3470 J/(kg °C). How many litres of water must the student evaporate from her body to reduce her temperature to 37.3°C. **(5 marks)**

QUESTION 4

(a) An industrial machine produces isotropic sound at an average power P. At a distance $r = 10$ m, the sound level is $\beta = 80$ dB.

(i) What is the intensity of the sound at the distance r? **(4 marks)**

(ii) What is the power of the sound source? **(3 marks)**

(b) A ground explosion occurs in a nearby quarry 20 km away from a student who has taken HSC107 at the Faculty of Health Sciences.Compare the time it would takes for the tremor and the sound to arrive at the site of the student. The density of the ground is 3000 kg/m^3, and its bulk modulus is 4.8×10^{10} Pa. **(6 marks)**

(c) Make a fully labeled sketch that shows how a virtual image is formed by a converging lens. **(4 marks)**

(d) The near point of a person is 5 m. What must be the focal length of the spectacle lenses for the person to read a book at a distance of 25 cm? **(4 marks)**

(e) What do you understand about the half-life of a radioactive sample? **(4 marks)**

QUESTION 5

(a) Consider the network shown in Figure 3.

(i) Find the effective resistance between points a and b, and b and c, R_{ab} abd R_{bc}, respectively. Also, find the effective resistance of the circuit R_{eff}. **(5 marks)**

(ii) What is the total current through the network? **(2 marks)**

(iii) What is the voltage drop V_{ab} between junctions a an b? **(2 marks)**

(iv) Determine the current and the power of the resistors, R_1 and R_2. **(4 marks)**

(v) Comment on the current and the power of the two resistors R_1 and R_2, **(4 marks)**

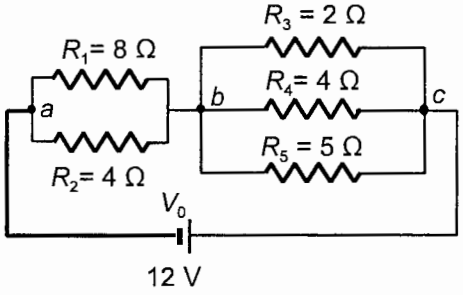

Figure 3.

(b) List the effects of electrical shocks on a human body. You do not have to include the corresponding current figures. **(4 marks)**

(c) Two foolish students A and B try to prove to each other what they know about electrical safety. Each works out the point to touch the system shown in Figure 4 so that they cannot be electrocuted. Student A determines that point a is safe while student B determines that the safe point should be point b. They cannot agree with each other and they each decide to touch their respective determined safe points as proof. Both students are in contact with the ground. With the aid of diagrams, explain which student will be safe and which one will not be safe. **(4 marks)**

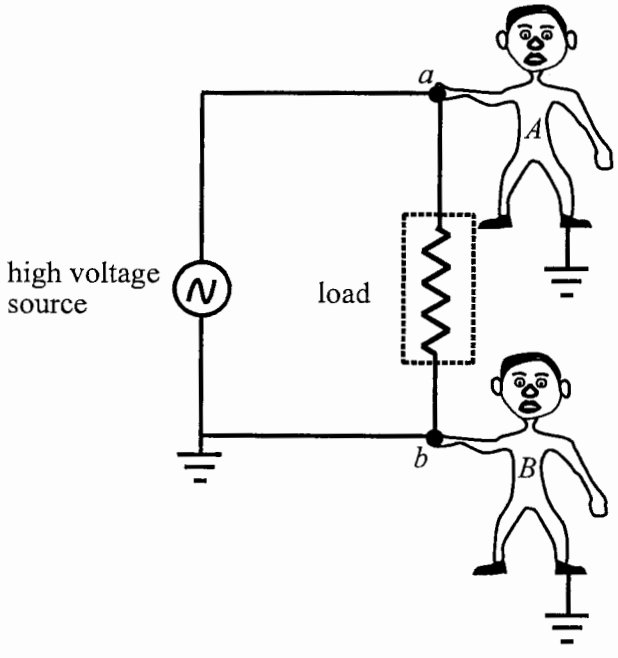

Figure 4.

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