UNIVERSITY OF SWAZILAND

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF ENVIRONMENTAL HEALTH

MAIN EXAMINATION 2014/2015

TITLE O F PAPER: PHYSICS FOR HEALTH SCIENCES

COURSE NUMBER: HSC107

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 $\vec{A} = 3\hat{\imath} - 4\hat{\jmath} + 6\hat{k}$ and $\vec{B} = -5\hat{\imath} + 3\hat{\jmath} - 4\hat{k}$, find the angle between the two vectors.

(i) Find the magnitude of each vector. **(2 marks)**
(ii) Find the dot product of the two vectors. **(3 marks)**
(iii) Find the angle between the two vectors. **(2 marks)**

(b) A body starts at the origin with a velocity of 3 m/s and accelerates at2 m/s^2for6 s, and then moves at constant velocity for 3 s after which it accelerates at - 3 m/s^2for4 s. Sketch

(i) the acceleration-time, **(5 marks)**
(ii) the velocity-time, and **(6 marks)**
(iii)the displacement-time graphs for this motion. **(7 marks)**

QUESTION 2

(a) When you bend your knee,the quadriceps muscle isstretched. This increases thetension in the quadriceps tendon attached to your kneecap(patella), which, in turn,increases the tension in thepatella tendon that attachesyour kneecap to your lower legbone (tibia). Simultaneously,the end of your upper leg bone(femur) pushes outward on thepatella. Figure 1 shows howthese parts of a knee joint are arranged. The tension in the quadriceps tendon is$T_q = 60$ N. Assume that the force N is horizontal. Neglect gravity and the tension in the fibular collateral ligament. The tendons are oriented as in the figure on the right?

(i) Find the force N exerted on the patellar. **(8 marks)**

(ii) What size force $Tp$is applied to by the patellar tendon? **(3 marks)**

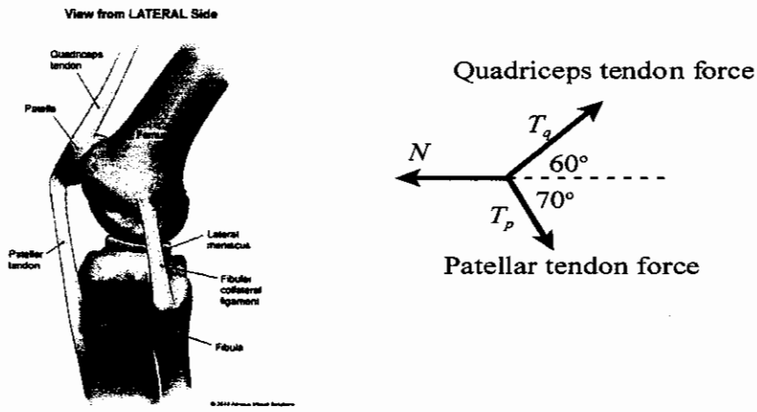


Figure 1.

(b) A person has a heart that functions as follows:

End-diastolic volume (EDV) = 120 ml, at 120 mmHg;
End –systolic volume (ESD) = 50 ml, at 70 mm Hg;
Heart rate = 75 bits per minute; and
Velocity of the blood = 30cm/s. The density of blood is 1060 kg/m^3.

Find

(i) the mean artery pressure, **(2 marks)**

(ii) the amount of blood pumped by the heart per pulse, **(2 marks)**

(iii) the work done by the heart to pump the blood per pulse, **(4 marks)**

(iv)the amount of work converted to kinetic energy per pulse, **(2 marks)**

(v) The amount of work converted to potential energy per pulse, and **(2 marks)**

(vi)the power of the heart. **(2 marks)**

QUESTION 3

(a) Sketch and describe a stress-strain diagram for a material with a hysteresis loop like some rubber materials and state where such can be used, and give an example of its application in everyday life. **(8 marks)**

(b) A box shapedplatform with an area of2 m × 3 m and a height of 0.5 mis to be used as a floatation device to support a patient of mass 60 kgto cross a river. Before the patient is loaded the platform floats to a depth of 10 cm, i.e. from the waterline to the top of the box is 40 cm.

(i) State Archimedes Principle. **(3 marks)**

(ii) Determinethe new depth of the platform below the waterline after the patient is loaded? **(7 marks)**

(c) A syringe has an inner diameter of 5.6mm and a needle inner diameter of 0.26mm. A nurse uses the syringe to inject medicine into a patient whose blood pressure is 140/100. What is the minimum force the nurse needs to apply to the syringe? **(7 marks)**

QUESTION 4

(a) The temperature of the normal human body temperature is 37 °C, what is this temperature in the Fahrenheit and Kelvin scales? **(4 marks)**

(b) A 50 kg student has a fever at 39.2 °C. The specific heat capacity of the human body is 3470 J/kg · K and the latent heat of vapourisation for water around these temperatures is 2.42×10^6J/kg. How much water must he sweat to cool off his body to a temperature of 37 °C. Give the mass in kg and the volume of the water in litres. **(6 marks)**

(c) An industrial machine produces isotropic sound of acoustic power of 2 W.

(i) Determine the distance where the sound level is 85 dB. **(8 marks)**

(ii) What is significant about the sound level of 85 dB? **(3 marks)**

(d) The far point of a person is 50 m. What should be the focal length of the spectacle lenses for the person to watch sports up to 500 m? **(4 marks)**

QUESTION 5

(a) Explain why hospital personnel must wear special conducting shoes (and not rubber shoes) while working in an oxygen enriched environment like an operating room. **(5 marks)**

(b) The resistance of a certain worker is found to be around 3000 Ω, including the shoes he is wearing. He touches an 11 kV line while standing on the ground.

(i) How much current flows through his body? **(2 marks)**

(ii) Can the worker be safe with such current going through his body? **(3 marks)**

(iii) Whywould a bird not be electrocuted sitting on the same power line? Use a diagram and equations to illustrate your answer. **(5 marks)**

(c) A faculty of health student uses a 15 W light bulb from 18:00 to 23:30 every day for 15 weeks while at the University. The cost of electricity is E1.09 per kWh. Find the total cost of the electricity consumed over this period? **(5 marks)**

(d) Under the pressure of examinations, a student uses a 220 V power-strip to try to power a 120 W electric iron, a 1500 W electric kettle, a 1000 W microwave oven and a1800 W hot plate at once. The circuit breaker is rated at 15 A. Determine whether these appliances can be use simultaneously.Find the current consumed by each of the four devices.

(5 marks)

DATA SHEET

General Data

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 $n_{air} = 1$
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

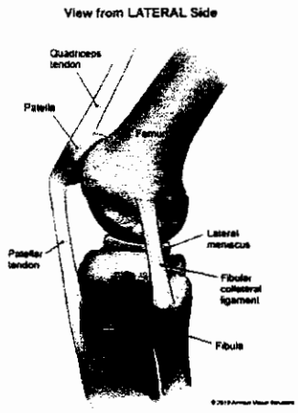
$c(water) = 4186$ J/(kg·K) $c(ice) = 2090$ J/(kg·K) $c(steam) = 2079$ J/(kg·K)
$L_f(ice) = 3.33 \times 10^5$ J/kg $L_v(water) = 2.260 \times 10^6$ J/kg
ρ (water) = 1000 kg/m^3 refractive index $n_w = 1.333$

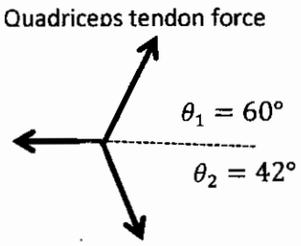
Electricity and nuclear data

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

$$MAP = P_{dia} + \frac{(P_{sys} - P_{dia})}{3}$$

$$P + \rho g y + \frac{1}{2}\rho v^2 = constant$$





(c) Three people are hired to paint the top part of a roof. Two of them are asked to stand up straight facing each other. Two planks are placed on their shoulder such that each one is straight from one person to the other. The other person climbs on the planks and starts painting. It is found that the average force used by the third person to paint the wall is 20 N, and the brush moves a total distance of 200 m during the painting period.

(i) What is the work done by each of the workers holding the planks? Justify you answer.

(ii) How much work is done by the third person doing the actual painting? Neglect the angle the brush makes with the wall. **(3 marks)**

(iii)eachpsystem shown in Figure 1 is to maintain a fractured leg in equilibrium. The required horizontal tension on the leg is $T' = 50$ N. Find the tension T in the cord and the mass m required. Neglect the masses and the friction of the pulleys. **(13 marks)**

(a) From your understanding of work, explain why you consider firewood to possess some energy. **(6 marks)**

(b) A glass vessel of mass $m = 300$ g falls from a cupboard shelf a height $h = 2$ m from the ground and the impact with ground lasts for 0.02 s. Find the force on of impact the glass and compare it with the weight of the glass. **(6 marks)**