UNIVERSITY OF SWAZILAND
DEGREE IN ENVIRONMENTAL HEALTH SCIENCE
EXAMINATION PAPER 2013/14

TITLE OF PAPER	:	PHYSICS FOR HEALTH SCIENCES
COURSE CODE	:	HSC 107
TIME	:	3 HOURS
TOTAL MARKS	:	102 MARKS
INSTRUCTIONS	:	THIS QUESTION PAPER HAS FIVE (5) QUESTIONS AND THE LAST PAGE CONTAINS DATA THAT MAY BE USEFUL IN SOME QUESTIONS
	:	ANSWER FOUR (4) QUESTIONS ONLY. **QUESTION TWO IS COMPULSORY**
	:	QUESTION TWO IS WORTH 27 MARKS AND THE REST OF THE QUESTIONS ARE 25 MARKS EACH
	:	GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW YOU ARRIVED AT AN ANSWER.
	:	NO FORM OF ANY PAPER SHOULD BE BROUGHT INTO NOR TAKEN OUT OF THE EXAMINATION ROOM
	:	BEGIN THE ANSWER TO EACH QUESTION ON A SEPARATE SHEET OF PAPER
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QUESTION 1

(a) Given two vectors $\vec{A}$ and $\vec{B}$, explain what is the meaning of the dot product $(\vec{A} \cdot \vec{B})$ of the two vectors. Also include an equation and illustrative diagram(s). **(7 marks)**

(b) A body starts at the origin with a velocity of 5 m/s and accelerates to 20 m/s in 3 s, and then moves at constant velocity for 4 s after which it accelerates to - 4 m/s in 6 s. Sketch

(i) the velocity-time, **(5 marks)**

(ii) the acceleration-time, and **(6 marks)**

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

QUESTION 2

(a) Figure 1 illustrates a traction system in equilibrium used to align a broken lower leg. The pulleys are frictionless. Note T_1 supports the leg, while T_2 aligns the leg.

(i) Find the magnitude of the force applied by the traction to the leg. **(4 marks)**

(ii) What angle does this force make with the horizontal? **(2 marks)**

(iii) Illustrate the angle the force makes with the horizontal. **(2 marks)**

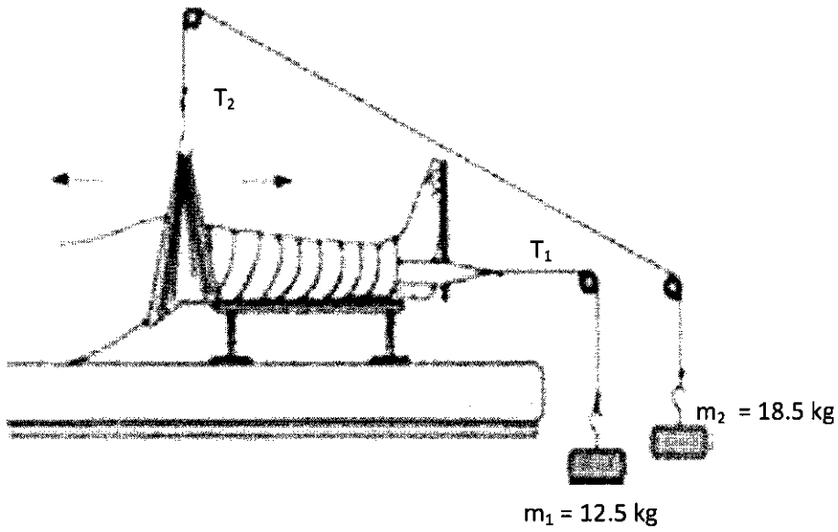

Figure 1.

(b) Define

(i) work, **(3 marks)**

(ii) energy, and **(3 marks)**

(iii) discuss one case where work was done in your life today (or where you observed work being done) and give the energy source used. **(3 marks)**

(c) A construction worker of mass 80 kg falls over a height of 20 m. The collision with the ground takes 0.05 s.

(i) Define force in terms of momentum. **(2 marks)**

(ii) Determine the force of impact with the ground. **(5 marks)**

(iii) Compare the force of impact to the weight of a 50 kg bag of cement, and use your own judgment to conclude as to whether the worker is likely to be injured in this collision. **(3 marks)**

QUESTION 3

(a) A human muscle of length $l_0 = 15$ cm with a cross-sectional area $A = 1.57 \times 10^{-4}$ m^2 is under a tension of 125 N. The muscle stretches by $\Delta l = 0.450$ mm under this load. Determine the Young's Y modulus for this muscle. **(5 marks)**

(b) With the aid of an equation, explain why it is much easier to cause damage with sharper objects than blunt objects? Give an example that supports your answer. **(6 marks)**

(c) State Pascal's law and give an example of its application in everyday life. Use equations in your explanation. **(6 marks)**

(d) A HSC107 student of mass $m = 65$ kg relaxes on a uniform Styrofoam slab of vertical thickness $h = 10$ cm and density 800 kg/m^3 floating on fresh water. The slab is floating such that its top surface coincides with the water level. First state Archimedes Principle and use this principle to find the thickness of the slab so that its top coincides with the level of the water. **(8 marks)**

QUESTION 4

(a) A solar water heater is used to heat 100 kg of water from 20°C to 60°C. The solar collector has an area of 6 m^2, and the sun's average intensity is 550 W/m^2.

(i) Calculate the solar energy power absorbed by the collector. **(3 marks)**

(ii) Calculate the energy needed to heat water at 20°C to 60°C. **(2 marks)**

(iii) Find the time it would take to heat the water? **(3 marks)**

(b) The sound level from a medical machine is 90 dB at a distance of 5 m. Assuming that the sound source is isotropic, what is the power generated by the source? **(8 marks)**

(c) Explain why if a pen is dipped in glass of water it appears bent upward. **(4 marks)**

(d) The near point of a person is 3 m. What should be the focal length of the spectacle lenses for the person to read a newspaper at 25 cm? **(5 marks)**

QUESTION 5

(a) Three resistors $R_1 = 3\ \Omega$, $R_2 = 6\ \Omega$ and $R_3 = 9\ \Omega$ are connected in parallel across an 18 V source.

(i) Find the current through each resistor. **(3 marks)**

(ii) Calculate the power delivered to each resistor. **(3 marks)**

(iii) What is the effective resistance of the network? **(3 marks)**

(b) What is a capacitor? Give one example of its application. **(4 marks)**

(c) A Faculty of Health Sciences student owns an electric space heater rated at 1500 W and 220 V rms. She turns on the heater at 6:00 p.m. and switches it off at 11:00 p.m.

(i) How much current is drawn by the heater? **(2 marks)**

(ii) What is the resistance of the heater filament? **(2 marks)**

(iii) How much energy in kilowatt-hours is consumed by the heater during the time it is on? **(2 marks)**

(iv) If electrical energy cost 105 cents per kilowatt-hour, what is the cost of the electricity consumed? **(2 marks)**

(d) A step down transformer is to be used to reduce the voltage from the 230 V rms wall socket voltage to 15 V rms in order to operate a music system. The transformer draws 500 mA from the wall socket.

(i) What is the turns-ratio of secondary to primary in the transformer? **(2 marks)**

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