UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

B.Sc.

Health Sciences HSC24: Physics for Life Sciences (Podiatry)

COURSE CODE : **HESC0024**

UNIT VALUE : **0.50**

DATE : **25-MAY-04**

TIME : **10.00**

TIME ALLOWED : **2 Hours 30 Minutes**

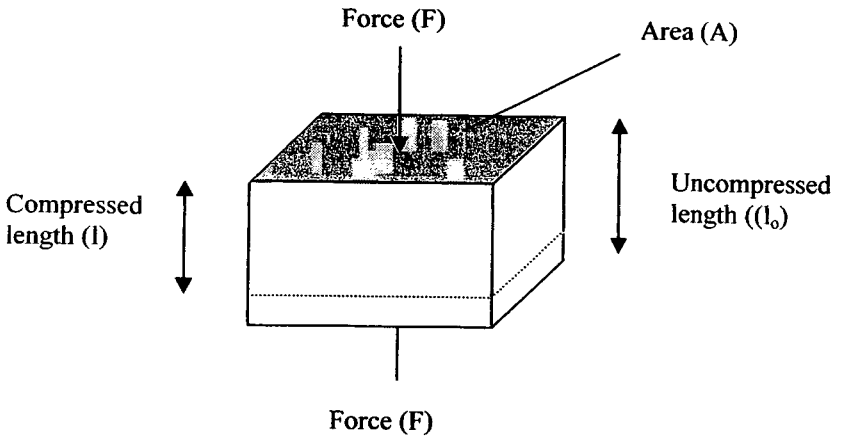
TURN OVER

Answer FOUR questions, selecting TWO from section A and TWO from section B. You are advised to divide your time equally between the four questions. With calculations be sure to show your workings.

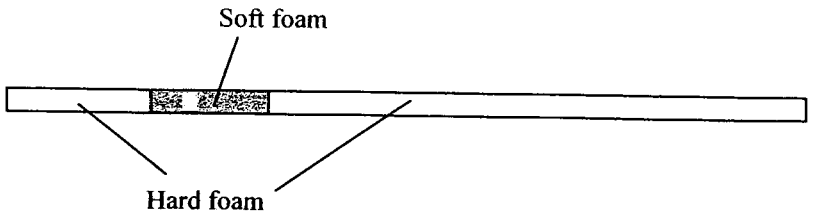
SECTION A (Questions 1-4)

1a. Using diagrams and notes, explain how a capacitive force plate for measuring the pressure distribution beneath feet works. (8 marks)

1b. The diagram below shows a piece of foam which is being compressed. Using the variables labelled in the diagram, define the *stress* and the *strain* which the foam is experiencing. Also, define its Young's modulus in terms of the stress and the strain. (6 marks)



1c. A podiatrist makes a foam shoe insert to relieve pressure over a vulnerable area of a patient's foot. (S)he uses two foams: a soft one over the vulnerable area and a harder one elsewhere, as shown in the diagram which is a vertical section through the insert.



What is the compression strain in the foam insert if it is 5 mm thick in its uncompressed state and compresses to 3 mm across its whole area when the patient stands on it? (2 marks)

1d. If the Young's modulus for the soft and hard foams is 60 kN/m^2 and 125 kN/m^2 respectively, calculate the compression stress in each of the two foams in the insert when it is compressed to 3 mm. (4 marks)

1e. What percentage stress (pressure) reduction has been achieved over the vulnerable part of the foot compared with the rest of the foot? (2 marks)

1f. In time the insert will need replacing due to a process called *creep*. Explain what *creep* is and what effect is has on the foam. (3 marks)

CONTINUED

2a. Explain what is meant by the *centre of gravity* of an object. (2 marks)

2b. Using diagrams and notes, describe the concept of the *base of support* of a standing person and use it to explain why a person with two walking sticks is generally more stable than someone with one stick who, in turn, is more stable than someone standing unaided. (6 marks)

2c. A man is laying in bed with his broken leg held in traction by a weight acting through two sets of three pulleys; one set attached to his foot, the other to the bed frame. Six strings pass between the two sets of pulleys. Sketch the arrangement. (5 marks)

2d. The traction force applied to his leg is 300 N. What is the mass of the weight on the end of the string? (3 marks)

2e. Why didn't the doctor just use a single string over a single pulley with a weight chosen to generate the same force as that provided by the weight and pulley system he did choose? (2 marks)

2f. If the pulleys pull the man's leg at an angle of 30^{o} to the horizontal, calculate the component of the traction force which is pulling him down the bed. (3 marks)

2g. The normal force between him and the bed is 700 N. What is the coefficient of friction between him and the bed if the traction force is just enough to start him slipping? (4 marks)

($g = 9.81 m/s^2$)

3a. Use a diagram and notes to explain how a Dewar flask is designed to inhibit heat transfer between its contents and the outside world. (5 marks)

3b. Ice can be applied to tissues in a variety of ways to produce cooling. Describe the four main ways and give an example of a situation in which you would use each of them. (4 marks)

3c. Define the *latent heat of fusion* and the *specific heat* of a substance. (4 marks)

3d. An ice pack is applied to a man's sprained ankle. The treatment involves 50 g of ice which starts out at $-2^{o}C$ and ends up as water at $12^{o}C$. If the cooled ankle tissue has a mass of 350 g, what is the average temperature drop produced in it? You may assume that all the heat used to melt and warm the ice/water came from the patient's ankle and ignore the effect of circulating blood on the temperature of his ankle. (6 marks)

3e. What mass of vapocoolant spray would be needed to have the same cooling effect as the ice in part 3d? (3 marks)

3f. Use a diagram and brief notes to describe how a cryoprobe based on the Joule-Kelvin effect works. (3 marks)

Specific heat of ice = 2.2 kJ/kg/^{o}C; Latent heat of fusion of ice = 30 kJ/kg/^{o}C;
Specific heat of water = 4.2 kJ/kg/^{o}C; Specific heat of ankle tissue = 4.0 kJ/kg/^{o}C
Latent heat of evaporation of vapocoolant spray = 1.5 MJ/kg

TURN OVER

4a. Define the *wavelength* and the *frequency* of an electromagnetic wave. How are they related? (6 marks)

4b. What is the wavelength of a radio wave of frequency 6.7×10^4Hz? (2 marks)

4c. State the *cosine rule* and the *inverse square law* for calculating the intensity of light falling on a patient's skin. (6 marks)

4d. An infra red lamp is set up so that its light falls at 90° to a patient's skin 300mm away. If the intensity of the light under these conditions is $1.2 W/cm^2$ what would it be if the lamp was adjusted so that it was 200mm away from the target tissues and the rays fell at 65° to the skin? (Hint: make the calculation in two stages, dealing with the changes in distance and in angle one at a time) (6 marks)

4e. The temperature of the infra red lamp is adjusted by means of a potentiometer. Use a diagram and notes to describe the construction of a simple potentiometer and explain how it is used to vary the voltage across a resistance such as a lamp element. (5 marks)

(speed of light in air = 3×10^8 m/s)

Section B (Questions 5-8)

5a. Use diagrams and notes to describe how a ruby laser works. (7 marks)

5b. Outline the main treatment parameters which should be recorded to describe a laser therapy session. Define carefully any technical terms you use in your description. (4 marks)

5c. How does the light from a ruby laser differ from that produced by an infrared lamp? What are the consequences for therapy? (4 marks)

5d. Create a table comparing and contrasting the strengths and limitations of wax baths and infrared lamps as means of heating tissues. (5 marks)

5e. What is a *laser cluster probe* and in what situations might you use it? (2 marks)

5f. A panel on the back of a laser indicates that it consumes power at a rate of 300 W. Which standard size fuse (3 A, 5 A or 13 A) should be fitted to its mains plug and why? Mains voltage is 230 V. (3 marks)

CONTINUED

6a. Using diagrams and notes describe how the *capacitor field* method and *inductothermy* method for shortwave diathermy work. Be sure to include a description of how each kind of treatment is set up and an explanation of the mechanisms of heat production. (10 marks)

6b. A shortwave diathermy machine is designed such that, when set up for the capacitor field method, it works best when the combined capacitance of its electrodes and the tuning capacitor is 10pF. If the capacitance of the electrodes when applied to the patient is 6pF, what capacitance should the tuning capacitor be adjusted to? (2 marks)

6c. What parameters should be recorded when ever a shortwave diathermy treatment is given. Define/explain any terms you use. (5 marks)

6d. Explain the safety precautions which should be taken before embarking on a shortwave diathermy treatment and in setting it up. (4 marks)

6e. Use a diagram and notes to describe how a defibrillator works. (4 marks)

7a. Explain briefly how an ultrasound beam is generated using the inverse piezo-electric effect. (3 marks)

7b. What is the *half value depth* of an ultrasound beam? Indicate with an annotated diagram how it varies with the frequency of the waves in the beam. (4 marks)

7c. Explain with notes and diagrams how Doppler ultrasound is used to "listen" to how fast blood flows. (6 marks)

7d. A conventional TENS machine is set up to deliver pulses of width 0.05 ms at 100 Hz. How long is it between the starts of two successive pulses? Draw the intensity/time graph for this arrangement. (Your time axis should extend over 100 ms.) (4 marks)

7e. A burst TENS treatment involves a burst frequency of 2 Hz a burst width of 0.2 s, a pulse frequency of 50 Hz, and a pulse width of 0.1 ms. How long is it between the starts of two successive pulses in a burst? Draw the intensity/time graph for this arrangement. Your time axis should extend over 1 s.) What is the duty cycle? (8 marks)

8a. Explain what you should do if you come across someone who appears to have suffered electrocution. (5 marks)

8b. Describe with a diagram and brief notes how surgical diathermy works. (5 marks)

8c. Describe with a diagram and brief notes how *iontophoresis* works. (5 marks)

8d. Explain with a diagram and notes how a sphygmomanometer works and is used. (5 marks)

8e. Describe what happens to tissues as they are heated from 37 °C to 500 °C. What impact does the rate of heating have on what happens? (5 marks)

END OF PAPER