FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MODULE: PHYL02E

PHYSICS FOR THE LIFE SCIENCES L02E

CAMPUS: APK

SUPPLEMENTARY EXAM 2016

EXAMINER: **MRS S JACOBS**

MODERATOR: **DR E CARLESCHI**

DURATION: 120 MINUTES **MARKS: 100**

NUMBER OF PAGES: 15 PAGES (excluding this information page)

INSTRUCTIONS:

1. Answer ALL the questions.
2. Programmable calculators are not permitted.

Question 1 [25]

1.1 A baseball is thrown horizontally with a velocity of 150 $km.h^{-1}$. Calculate how far the ball falls vertically by the time it reaches the catcher's glove 20 m away. **[3]**

1.2 Derive the relation for the centripetal acceleration in terms of velocity and radius of path for an object in uniform circular motion. Use a suitable diagram and explain all steps and symbols. **[6]**

1.3 The average velocity of a backpacker as she reaches her destination is 1 $m.s^{-1}$ due west. This average velocity is the result of her hiking for 6 km with an average velocity of $3m.s^{-1}$ due west, turning around, and hiking with an average velocity of 0.3 $m.s^{-1}$ due east. Calculate (in kilometres) how far she walked. **[5]**

1.4 Explain how the human body detects acceleration of the head. **[4]**

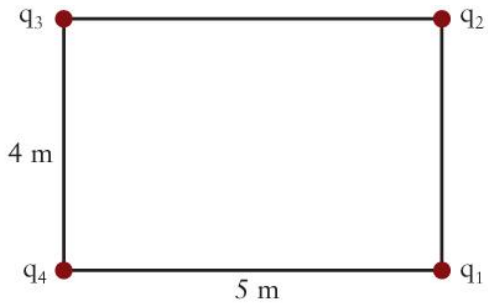
1.5 A ball is thrown upward from the ground with an initial speed of 25 $m.s^{-1}$. At the same instant, another ball is dropped from a building 15 m high. Calculate after how long will the two balls be at the same height. **[5]**

1.6 If the velocity of a particle is non zero, can the particle's acceleration be zero? Explain your answer. **[2]**

Question 2 [16]

2.1 How far apart are a proton and electron if they experience an electric force of 1N?
Given: $k_e = 9 \times 10^9$ N.m^2.C^{-2}, charge of electron = -1.6×10^{-19} C and charge of proton = 1.6×10^{-19} C **[3]**

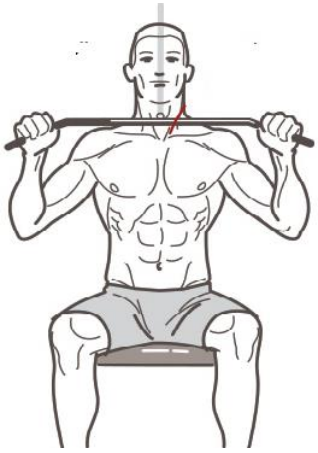
2.2 Four charges $q_1 = 100$ µC, $q_2 = 45$ µC, $q_3 = -125$ µC and $q_4 = 25$ µC are fixed at the corners of a 4 m by 5 m rectangle as shown in the figure below. Calculate the magnitude and direction of the net force acting on q_1.
Given: $k_e = 9 \times 10^9$ N.m^2.C^{-2} **[6]**



2.3 A force is applied to the right to accelerate a sled through loosely packed snow. Draw a free body diagram for the sled. **[2]**

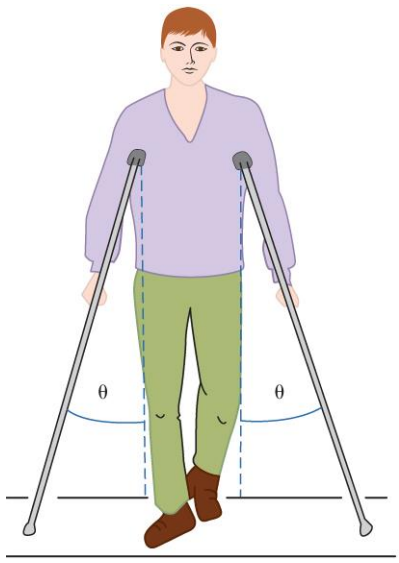
2.4 Figure shows a man of mass 70 kg intending to do closed grip lat pulldowns in the gym. In this exercise, the person pulls the weight of the upper body (arms, head and trunk) upward using a handle while the legs are wedged under a restraint pad. Calculate the magnitude of the force exerted by the handle on each of the man's hands. **[5]**

Given: Mass of trunk = 48% of total body mass, mass of head = 7% of total body mass and mass of each arm = 6.5% of total body mass.

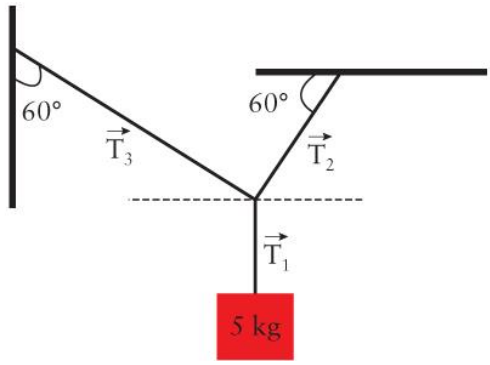


<u>Question 3</u> [30]

3.1 Figure shows a man (mass = 70 kg) using crutches. The crutches each make an angle of $\theta = 25^{o}$ with the vertical. Half the man's weight is supported by the crutches and the other half is supported by the normal forces acting on the soles of the feet. Assuming the man is motionless; calculate the magnitude of the force supported by each crutch. **[5]**



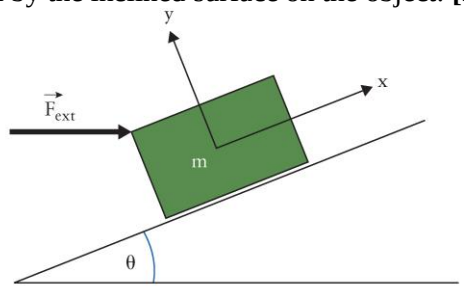
3.2 A 5 kg block is suspended by three taut strings as shown in the figure below. Calculate the tension in the strings. **[5]**



3.3 Figure below shows an object on a frictionless surface that forms an angle $\theta = 40^{o}$ with the horizontal. The object is pushed by a horizontal external force such that it moves with constant speed. If the mass of the object is 75 kg, calculate

(a) the magnitude of the external force **[5] and**

(b) the magnitude of the force exerted by the inclined surface on the object. **[3]**



3.4 Sue was driving on a country road at 80 $km.h^{-1}$. On seeing a deer standing in the middle of the road in front of her, she applies her brakes.

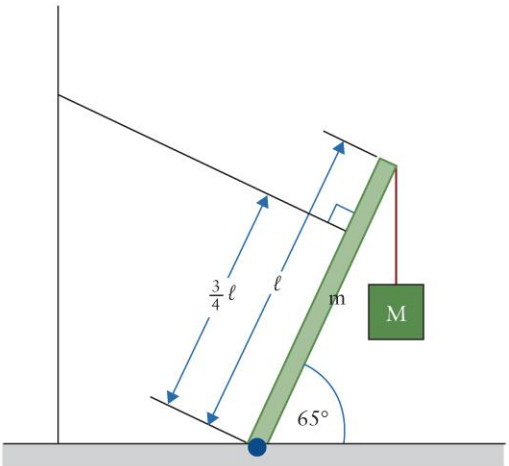
(a) If it took her 2 s to react and the deer was 200 m away from her, calculate what Sue's acceleration should be in order to avoid hitting the deer. **[5]**

(b) If she gained this acceleration from the road by the kinetic friction between the road and the sliding tyres, calculate the coefficient of kinetic friction. **[2]**

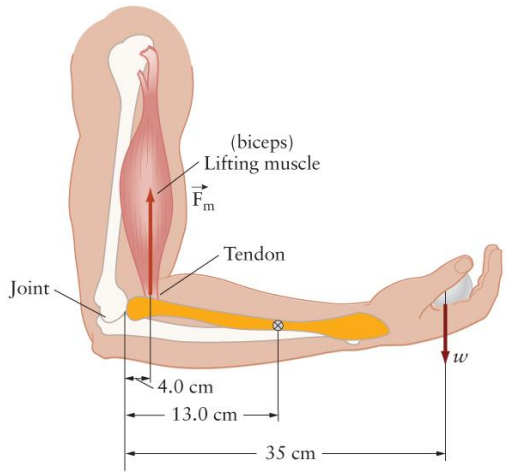
3.5 Show that the total linear momentum of an isolated system is constant. Explain all the steps and symbols. **[5]**

<u>Question 4</u> [29]

4.1 Figure shows a uniform boom of mass m = 120 kg supported by a cable perpendicular to the boom. The boom is hinged at the bottom and an object of mass M = 200 kg hangs from its top. Calculate,
(a) the tension in the massless cable **[5] and**
(b) the components of the force exerted on the boom at the hinge. **[4]**



4.2 The figure below shows a horizontal forearm held perpendicular to the upper arm. A 70 N weight is held in the hand. Neglect the weight of the forearm.



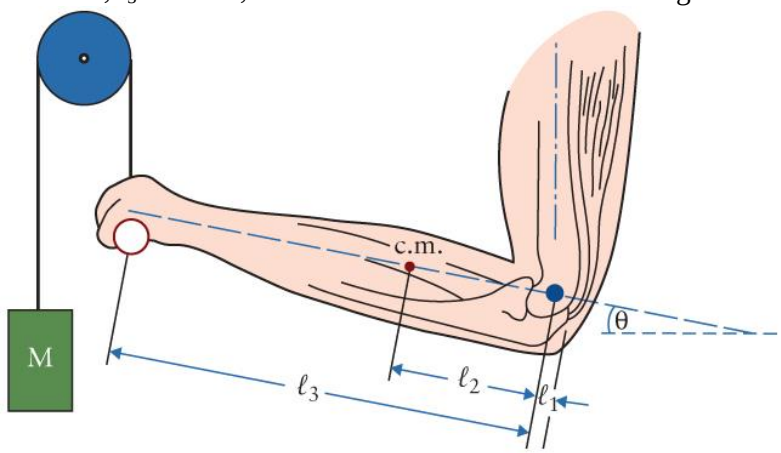
(a) Calculate the torque about the joint due to the 70 N weight. **[2]**
(b) Calculate the magnitude of the force, T, on the forearm by the biceps. **[3]**

4.3 An object of mass M = 10 kg is lifted by a man with the aid of a pulley as shown in the figure below. The upper arm is held vertical and the lower arm has an angle of $\theta = 35^{o}$ with the horizontal. Label "c.m" marks the centre of mass of the lower arm. Calculate:

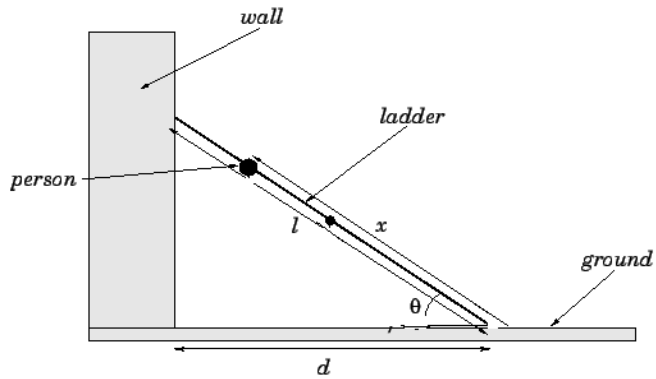
(a) the magnitude of the vertical force exerted on the lower arm by the triceps muscle, **[4] and**

(b) the magnitude of the vertical force exerted on the lower arm by the humerus. **[3]**

<u>Given</u>: l_1 = 2 cm, l_2 = 15 cm, l_3 = 40 cm, mass of lower arm and hand = 2.3 kg



4.4 A uniform ladder of mass m = 40 kg and length l = 10 m leans against a smooth vertical wall as shown in figure below. A person of mass M = 80 kg stands on the ladder at a distance x = 7 m from the bottom as measured along the ladder. The foot of the ladder is d = 1.2 m from the bottom of the wall. Calculate,
(a) the force exerted by the wall on the ladder **[4] and**
(b) the normal force exerted by the floor on the ladder. **[4]**



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