1 **(a)** Define *moment of a force*.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

..... **[1]**

(b) State the two conditions that apply when an object is in equilibrium.

1. .....

2. ..... **[2]**

(c) Fig. 4.1 is a diagram of a human arm lifting an object.

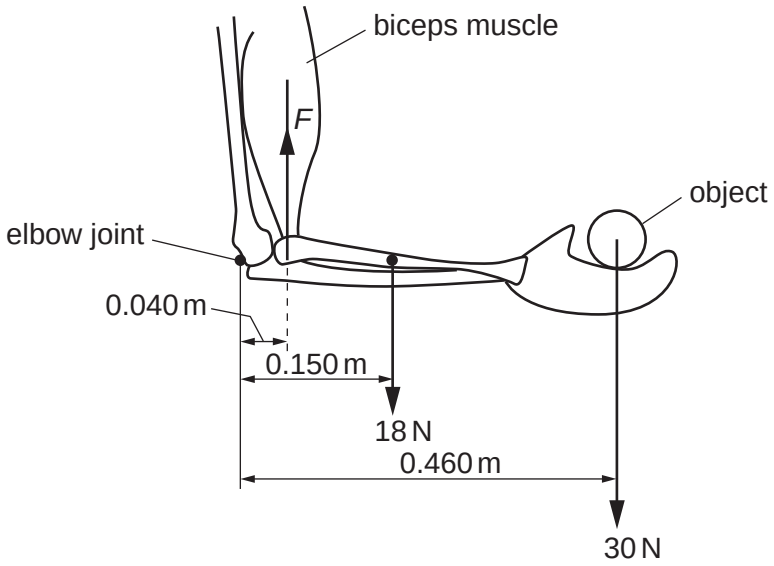

Fig. 4.1

The lower arm is horizontal and its centre of gravity is 0.150 m from the elbow joint. The weight of the lower arm is 18 N. The biceps muscle exerts a vertical force *F* on the arm. The horizontal distance between the elbow joint and the point of attachment of the muscle to the lower arm bone is 0.040 m. The weight of the object held in the hand is 30 N and its centre of gravity is 0.460 m from the elbow joint. The arm is in equilibrium.

(i) Define *centre of gravity.*

.....

..... **[1]**

(ii) Calculate the total clockwise moment about the elbow joint.

total clockwise moment = ... N m **[2]**

(iii) As the lower arm is moved away from the body, the force *F* exerted by the biceps muscles acts at an angle θ to the vertical as shown in Fig. 4.2.

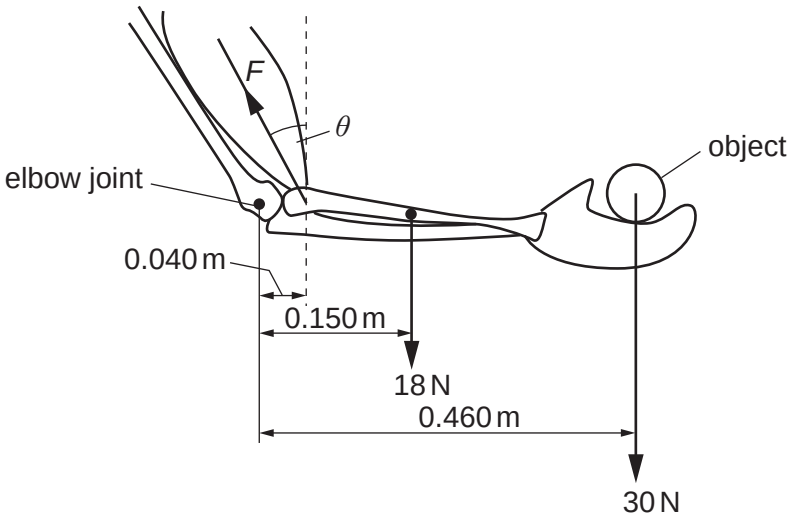

Fig. 4.2

The lower arm remains horizontal and in equilibrium. Describe and explain what happens to each of the following quantities as the angle θ is increased

1 the anticlockwise moment about the elbow joint

.....

.....

2 the magnitude of the force *F*.

.....

.....

.....

..... **[3]**

[Total: 9]

2 Fig. 5.1 shows a person standing in a stationary lift.

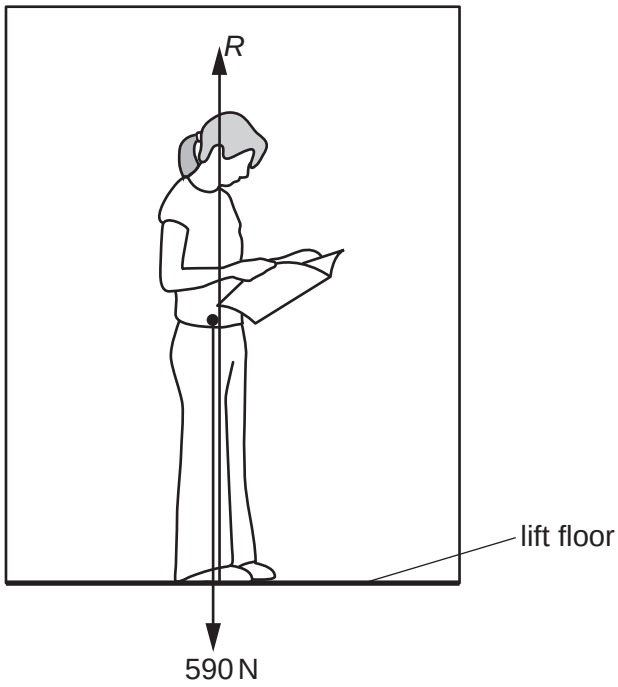

Fig. 5.1

There are only two forces acting on the person. The weight of the person is 590 N. The vertical contact force acting on the person from the floor of the lift is *R*.

(a) Show that the mass of the person is 60 kg.

[1]

(b) The lift starts from rest. It has a constant upward acceleration of 0.50 m s^{-2}. Calculate the magnitude of the contact force *R*.

R = ... N **[2]**

(c) After a short period of acceleration, the lift travels upwards at a constant velocity. Explain why the force *R* is equal to the weight of the person when the lift travels at a constant velocity.

.....

.....

..... **[1]**

(d) State and explain how the force *R* changes at the instant the lift starts to decelerate.

.....

.....

.....

..... **[2]**

[Total: 6]

3 **(a)** Write a word equation for *kinetic energy*.

kinetic energy =

[1]

(b) A bullet of mass 3.0×10^{-2} kg is fired at a sheet of plastic of thickness 0.015 m. The bullet enters the plastic with a speed of 200 m s^{-1} and emerges from the other side with a speed of 50 m s^{-1}.

Calculate

(i) the loss of kinetic energy of the bullet as it passes through the plastic

loss of kinetic energy = ... J **[3]**

(ii) the average frictional force exerted by the plastic on the bullet.

frictional force = ... N **[2]**

[Total: 6]

4 Use your knowledge of physics to state if each statement is correct or incorrect. You then need to explain the reason for your answer. An example has been done for you:

In a vacuum, a 2.0 kg object will fall faster towards the ground than an object of mass 1.0 kg.

This statement is **incorrect**.
Explanation: **All objects falling towards the Earth in a vacuum have the same acceleration**.

(a) The mass of a particle (e.g. electron) remains constant as its speed approaches the speed of light.

This statement is .....

Explanation: .....

.....

..... **[2]**

(b) A ball is thrown vertically upwards. Air resistance has negligible effect on its motion. During the flight, the total energy of the ball remains constant.

This statement is .....

Explanation: .....

.....

..... **[2]**

(c) An object falling through air has a terminal velocity of 30 m s^{-1}. At terminal velocity, the weight of the object is equal to the acceleration of free fall.

This statement is .....

Explanation: .....

.....

..... **[2]**

(d) The technique of 'triangle of vectors' is used by a global positioning system (GPS) to locate the position of cars.

In your answer, you should use appropriate technical terms, spelled correctly.

This statement is .....

Explanation: .....

.....

..... **[2]**

5 **(a)** Explain in terms of forces what is meant by a *couple*.

In your answer, you should use appropriate technical terms, spelled correctly.

.....

.....

..... **[1]**

(b) **(i)** Define *moment of a force*.

.....

..... **[1]**

(ii) Fig. 6.1 shows three forces acting on a rod.

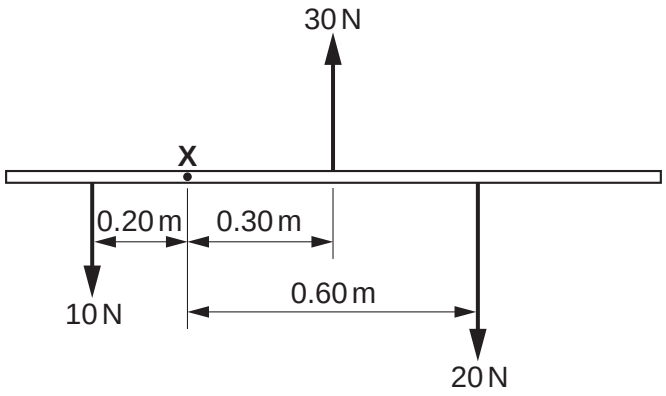

Fig. 6.1

By taking moments about point **X**, show that the rod is not in equilibrium when acted upon by these forces.

.....

..... **[2]**

[Total: 4]

6 Fig. 2.1 shows two masses **A** and **B** tied to the ends of a length of string. The string passes over a pulley. The mass **A** is held at rest on the floor.

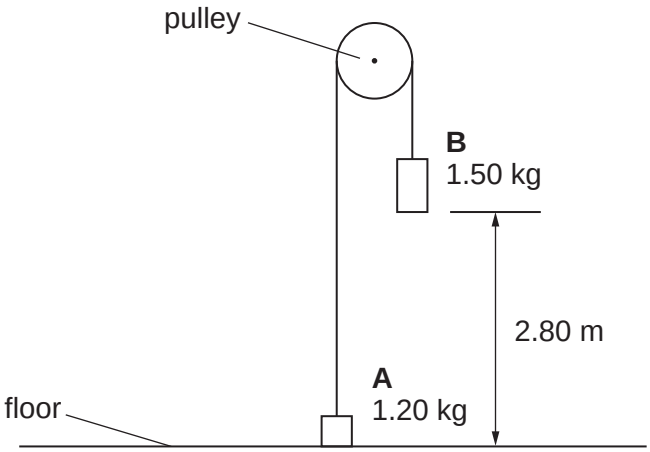

Fig. 2.1

The mass **A** is 1.20 kg and the mass **B** is 1.50 kg.

(a) Calculate the weight of mass **B**.

weight = ... N **[1]**

(b) Mass **B** is initially at rest at a height of 2.80 m above the floor. Mass **A** is then released. Mass **B** has a constant downward acceleration of 1.09 m s^{-2}. Assume that air resistance and the friction between the pulley and the string are negligible.

(i) In terms of forces, explain why the acceleration of the mass **B** is less than the acceleration of free fall *g*.

.....

..... **[1]**

(ii) Calculate the time taken for the mass **B** to fall 1.40 m.

time = ... s **[3]**

(iii) Calculate the velocity of mass **B** after falling 1.40 m.

velocity = ... $m\,s^{-1}$ **[2]**

(iv) Mass **B** hits the floor at a speed of 2.47 $m\,s^{-1}$. It **rebounds** with a speed of 1.50 $m\,s^{-1}$. The time of contact with the floor is 3.0×10^{-2} s. Calculate the magnitude of the average acceleration of mass **B** during its impact with the floor.

acceleration = ... $m\,s^{-2}$ **[2]**

[Total: 9]

7 A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

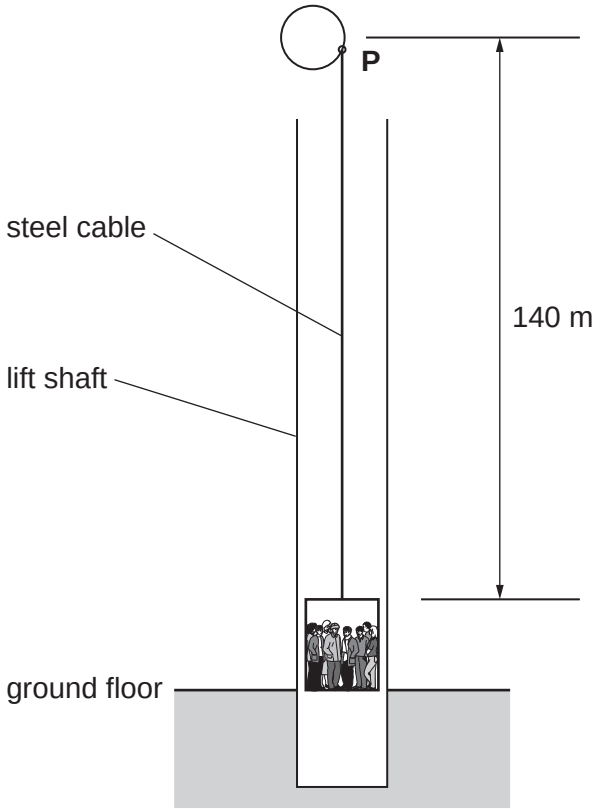

Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) **(i)** The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,m\,s^{-2}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,N$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]