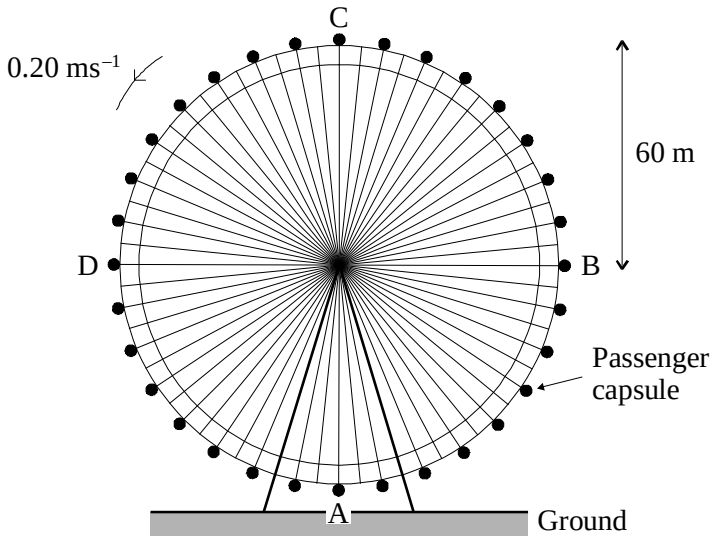
Force Questions

8. The 'London Eye' is a large wheel which rotates at a slow steady speed in a vertical plane about a fixed horizontal axis. A total of 800 passengers can ride in 32 capsules equally spaced around the rim.

A simplified diagram is shown below.



On the wheel, the passengers travel at a speed of about 0.20 m s^{-1} round a circle of radius 60 m. Calculate how long the wheel takes to make one complete revolution.

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Time = ...

(2)

What is the change in the passenger's velocity when he travels from point B to point D?

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(2)

When one particular passenger ascends from point A to point C his gravitational potential energy increases by 80 kJ. Calculate his mass.

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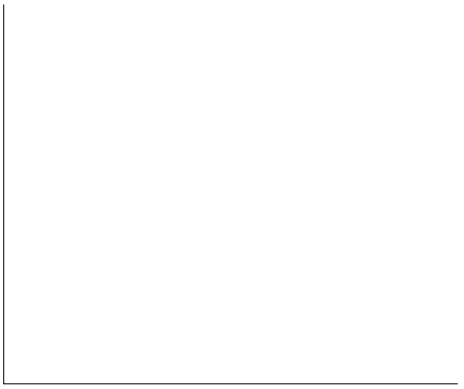
Mass =.....

(3)

On the axes below sketch a graph showing how the passenger's gravitational potential energy would vary with time as he ascended from A to C. Add a scale to each axis.



(3)

Discuss whether it is necessary for the motor driving the wheel to supply this gravitational potential energy.

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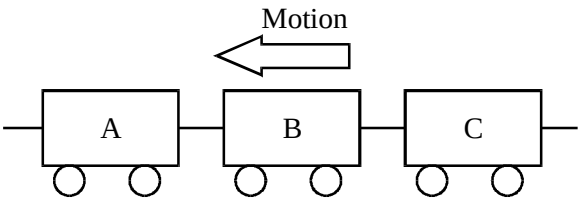
(2)
(Total 12 marks)

9. The diagram shows three trucks which are part of a train. The mass of each truck is 84 000 kg.



The train accelerates uniformly in the direction shown from rest to 16 m s^{-1} in a time of 4.0 minutes. Calculate the resultant force on each truck.

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Resultant force =.....

(3)

The force exerted by truck B on truck C is 11 200 N. Draw a free-body force diagram for truck B, showing the magnitudes of all the forces. Neglect any frictional forces on the trucks.

(4)

The total mass of the train is 3.0×10^6 kg. Calculate the average power delivered to the train during the accelerating process.

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Average power =.....

(3)

The locomotive is powered by an overhead cable at 25 kV. Neglecting any power dissipation, calculate the average current drawn from the supply during the accelerating period.

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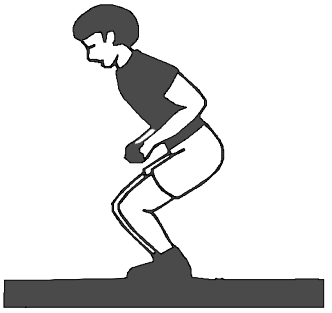
Average current =.....

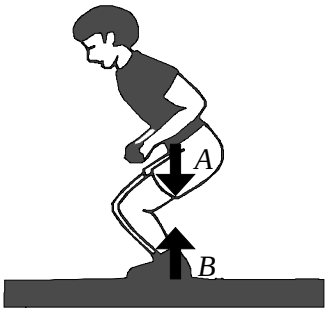
(2)

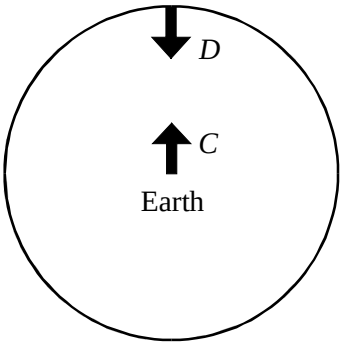
(Total 12 marks)

10. A child is crouching at rest on the ground



Below are free-body force diagrams for the child and the Earth.





Complete the following table describing the forces *A*, *B* and *C*.

Force	Description of force	Body which exerts force	Body the force acts on
A	Gravitational	Earth	Child
B			
C			

(4)

All the forces *A, B, C* and *D* are of equal magnitude.

Why are forces *A* and *B* equal in magnitude?

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Why must forces *B* and *D* be equal in magnitude?

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(2)

The child now jumps vertically upwards. With reference to the forces shown, explain what he must do to jump, and why he then moves upwards.

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(3)
(Total 9 marks)

11. State in words how to calculate the work done by a varying force.

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(2)

Under what circumstances is the work done by a force negative?

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What happens to the kinetic energy of the body on which the force acts in such circumstances?

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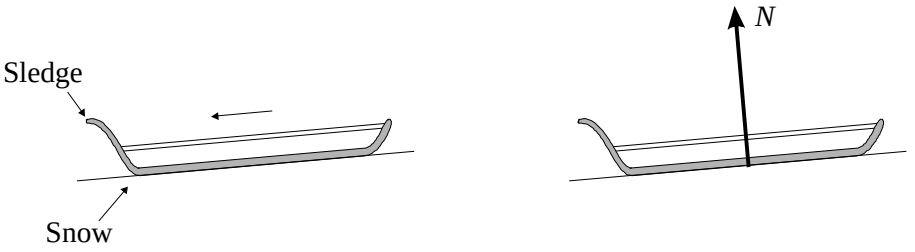
(2)

A runaway sledge slides down a slope at a constant speed. One force is shown on the free-body diagram of the sledge. It is the normal contact push of the snow on the sledge.



Add to the free-body diagram to show the other two forces acting on the sledge. Name each force and state what is producing it.

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(3)

The sledge slides 15 m down the slope at a constant speed. The force N = 40 N.

What is the resultant force acting on the sledge?

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What is the work done by the force N?

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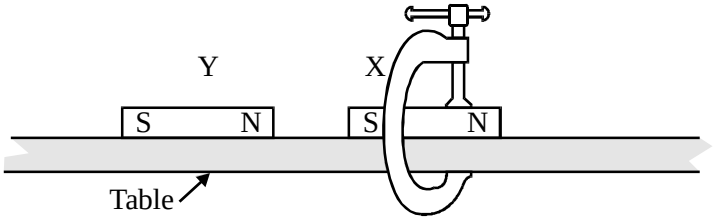
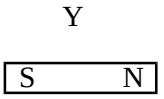
(2)
(Total 9 marks)

12. A magnet X is clamped to a frictionless table. A second magnet Y is brought close to X and then released.



Add labelled forces to the free-body diagram below for magnet Y to show the forces acting on it just after it is released.



(3)

According to Newton's third law, each of the forces in your diagram is paired with another force. Write down one of these other forces, stating its direction and the body it acts upon.

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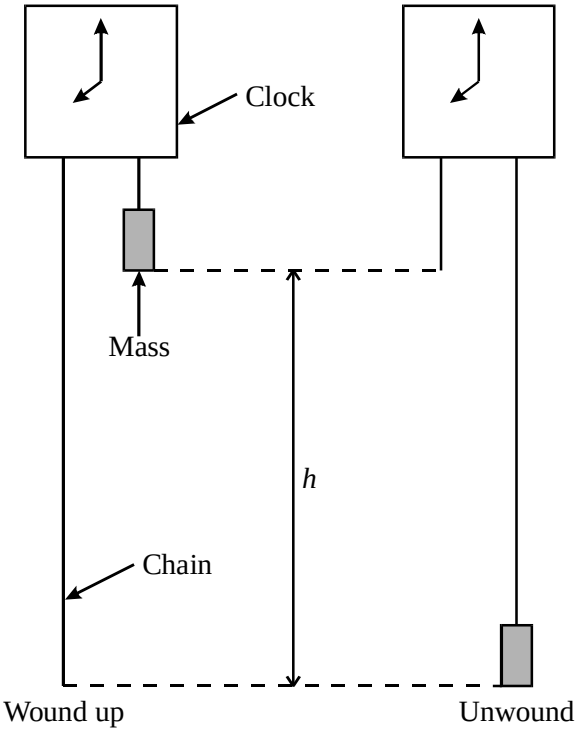
(2)
(Total 5 marks)

13. A "grandfather" clock is a type of clock where the energy needed to provide the movement of the hands comes from a falling mass.



To wind up the clock, the mass has to be raised a distance *h*.

In one such clock, the mass is a steel cylinder of diameter 0.060 m and height 0.17 m. Show that its mass is approximately 4 kg.
(The density of steel is 7.8×10^3 kg m^{-3}.)

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(3)

The distance fallen by the mass is 1.1 m. Calculate the change in its gravitational potential energy.

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Change in G. P. E. = ...

(2)

The clock has to be wound up once per week. Calculate the average power output of the falling mass.

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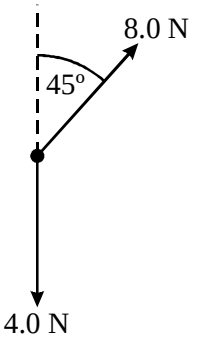
Power = ...

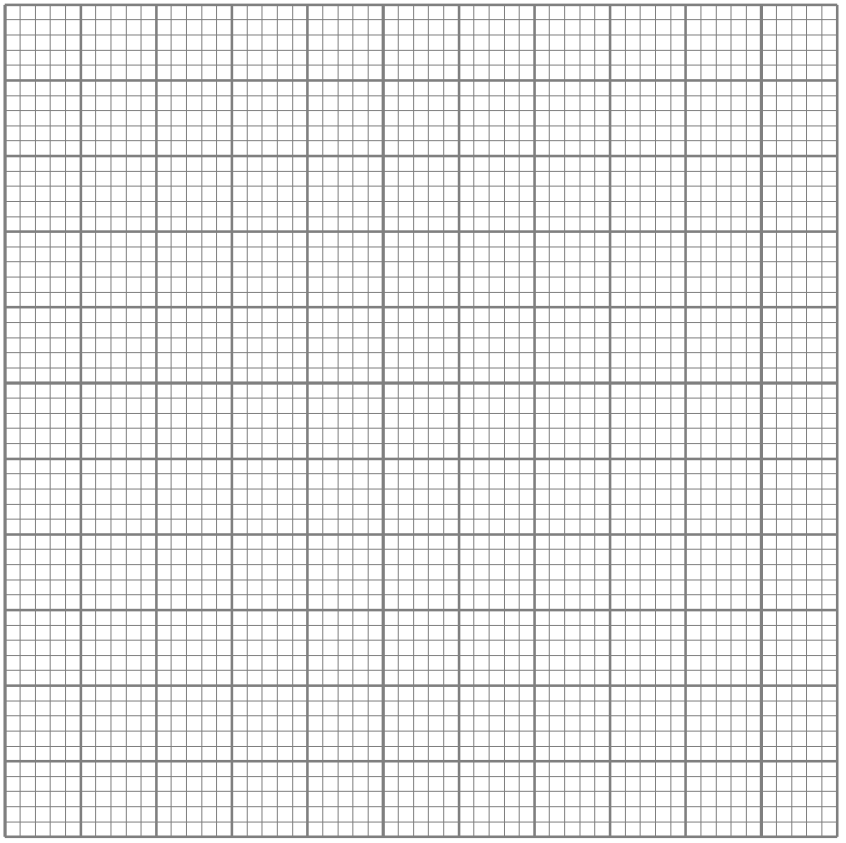
(3)

(Total 8 marks)

14. The diagram shows two forces acting on a body.



On the grid below draw a scale diagram to determine the resultant force acting on the body. Use a scale of 1 cm to 1 N.



State the magnitude of the resultant force.

Force = ...

(4)

What name is given to physical quantities which add by the same rule as forces?

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Name **two** other examples of such physical quantities.

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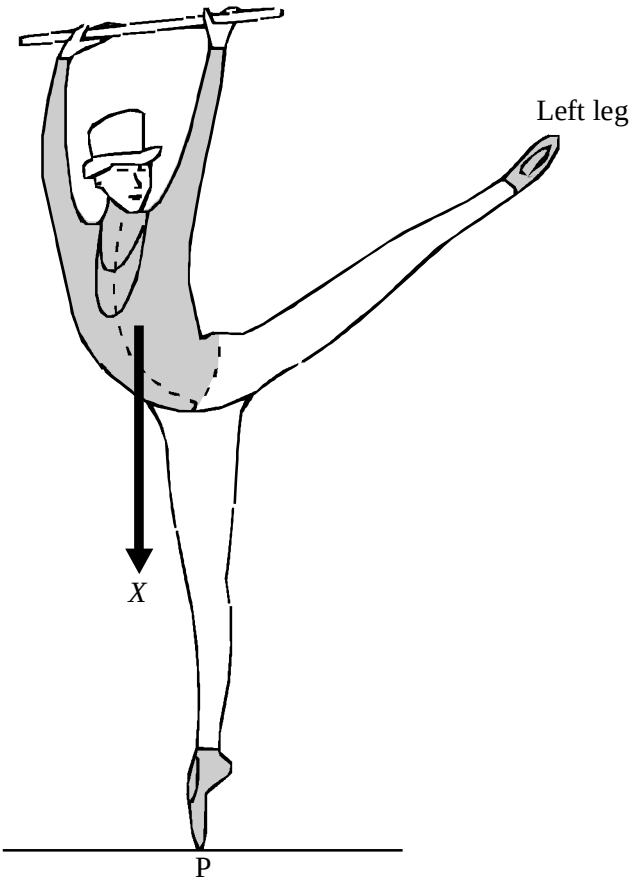
(2)
(Total 6 marks)

15. The diagram shows a ballet dancer balancing on the point P of her right foot, with her left leg extended.



The arrow labelled X represents the weight of the whole of her body apart from her legs.

Add a second arrow to the diagram to represent the weight of her extended left leg.
Label this arrow Y.

Add a third arrow, labelled Z, to represent the weight of her right leg.

(2)

With reference to the relative sizes and positions of these forces, explain how this situation illustrates the principle of moments. You may be awarded a mark for the clarity of your answer.

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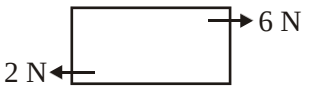
(5)
(Total 7 marks)

16. Determine the resultant force on the object below.



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(1)

What can be deduced about the motion of an object

(i) when the resultant force on it is zero,

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(ii) when the resultant force on it is vertically upwards,

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.....

(iii) when the resultant force on it is in the opposite direction to its motion?

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(3)

Newton's third law of motion is sometimes stated in the form: "To every action there is an equal and opposite reaction". A student argues that, in that case, the resultant force on an object must always be zero and so it can never be moved. Explain what is wrong with the student's argument.

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(2)
(Total 6 marks)

17. Complete the table below by giving **one** example of each type of force.

Type of force	Example
Gravitational	
Electromagnetic	
Nuclear	

(3)

The diagram shows forces acting on the Sun and the Earth. These forces form a Newton's third law pair.

State three properties of these forces which are necessary for them to be a Newton's third law pair.

1. …….

2. …….

3. …….

(3)
(Total 6 marks)

18. A man is pushing a shopping trolley at a speed of 1.10 m s^{-1} along a horizontal surface. There is a constant frictional force opposing the motion. The man stops suddenly, letting go of the trolley, which rolls on for a distance of 1.96 m before coming to rest. Show that the deceleration of the trolley is approximately 0.3 m s^{-2}.

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(3)

The total mass of the trolley and its contents is 28.0 kg. Calculate the frictional force opposing its motion.

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…….

…….

Frictional force = ...

(2)

Calculate the power needed to push the trolley at a steady speed of 1.10 m s^{-1}.

…….

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…….

Power = …….

(2)

The man catches up with the trolley. Calculate the steady force he must now apply to it to accelerate it from rest to 1.10 m s^{-1} in 0.900 s.

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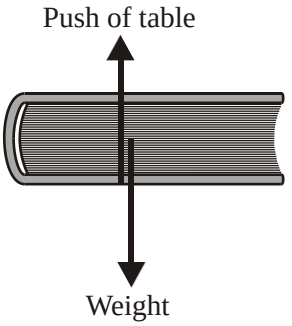
…….

Force = …….

(3)

(Total 10 marks)

19. A book is resting on a table. A student draws a correct free-body force diagram for the book as shown below.



The student makes the incorrect statement that "The forces labelled above make a Newton third law pair; therefore the book is in equilibrium". Criticise this statement.

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(3)

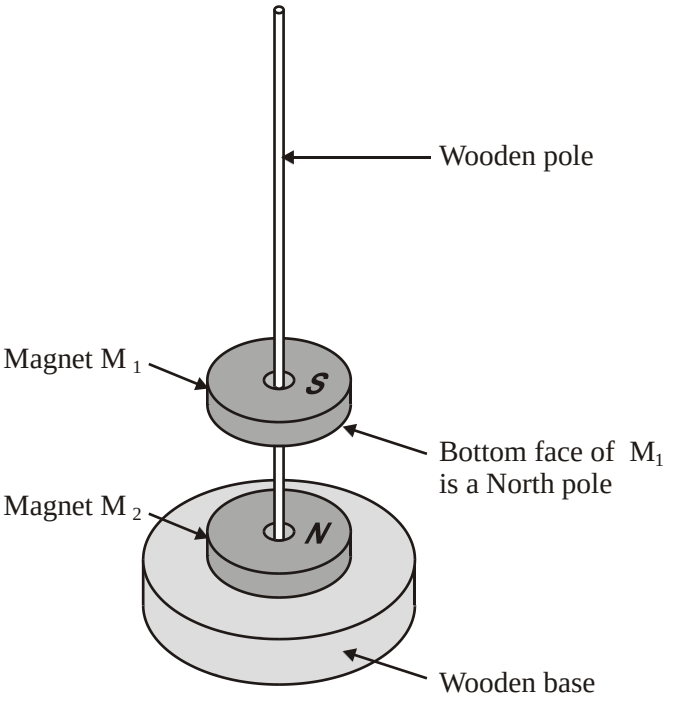
Each of the forces shown in the diagram has a 'pair' force related to it by Newton's third law. Complete the table below.

Force	Type of force	Direction of Newton 3rd law 'pair' force	Body 'pair' force acts upon
Weight			
Push of table	Electromagnetic		

(4)

(Total 7 marks)

20. The diagram shows two magnets, M_1 and M_2, on a wooden stand. Their faces are magnetised as shown so that the magnets repel each other.



(a) Draw a fully labelled free-body force diagram for the magnet M_1 in the space below.

(2)

(b) The table gives the three forces acting on the magnet M_2. For each force on M_2 there is a corresponding force known as its 'Newton's third law pair'. In each case state

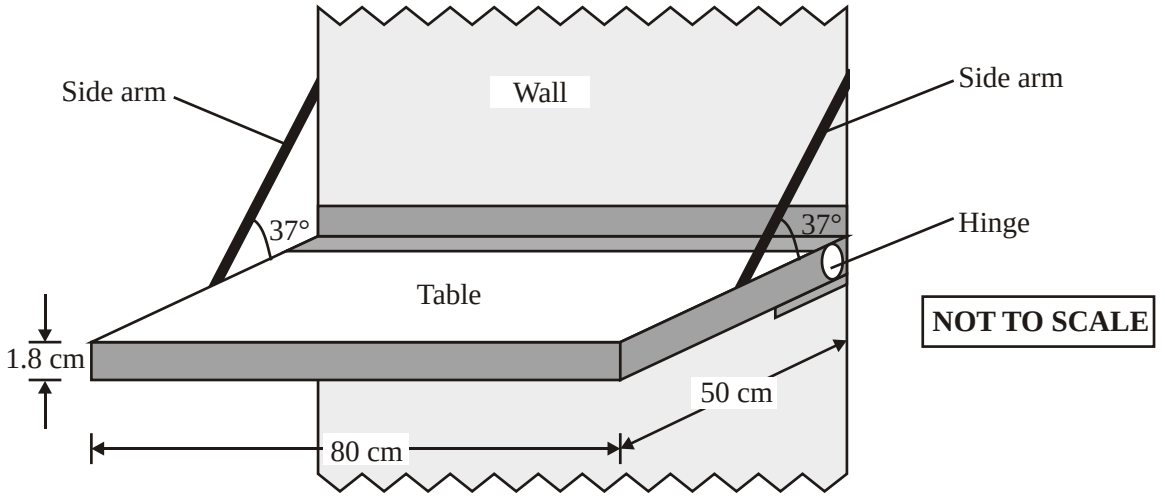
(i) the body on which this corresponding force acts,

(ii) the direction of this corresponding force.

Force on M_2	Body on which corresponding force acts	Direction of the corresponding force
Contact		
Magnetic		
Weight		

(6)
(Total 8 marks)

21. (a) The diagram below shows a drop-down table attached to a wall. The table is supported horizontally by two side arms attached to the mid-points of the sides of the table.



The table surface is 80 cm long, 50 cm deep and 1.8 cm thick. It is made from wood of density 0.70 g cm^{-3}. Show that its weight is about 50 N.

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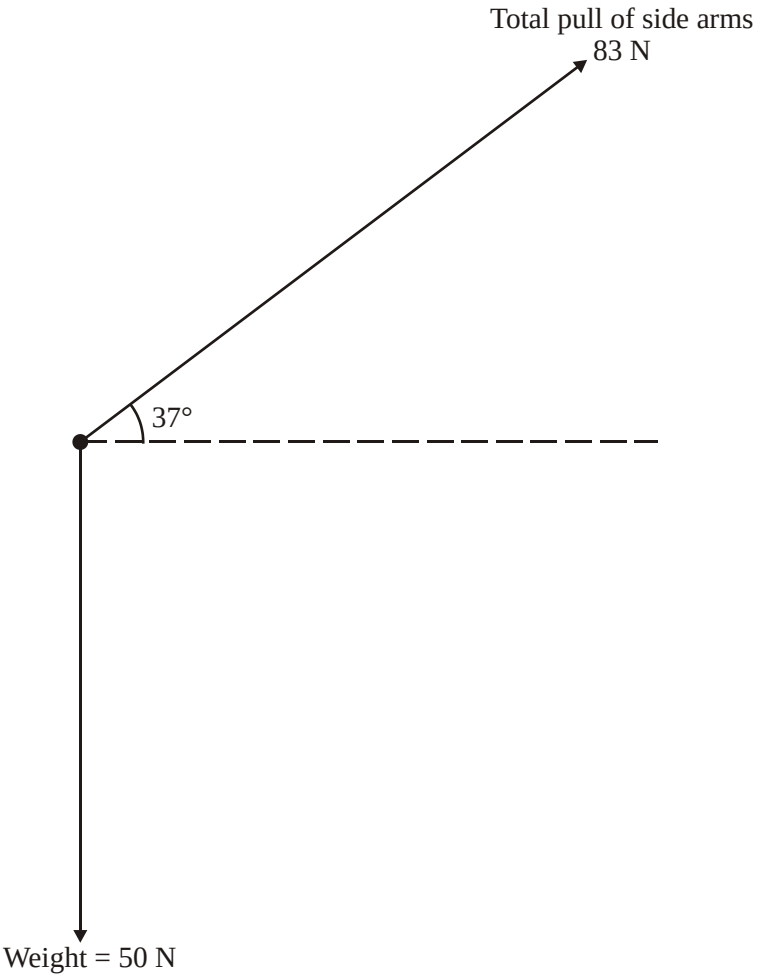
(3)

(b) The free-body force diagram below shows two of the three forces acting on the table top.



(i) Calculate the horizontal and vertical components of the 83 N force.

Horizontal component: .....

.....

Vertical component: .....

.....

(2)

(ii) Add appropriately labelled arrows to the free-body force diagram to show these components.

(1)

(iii) Hence find the magnitude of the horizontal force that the hinge applies to the table top and state its direction.

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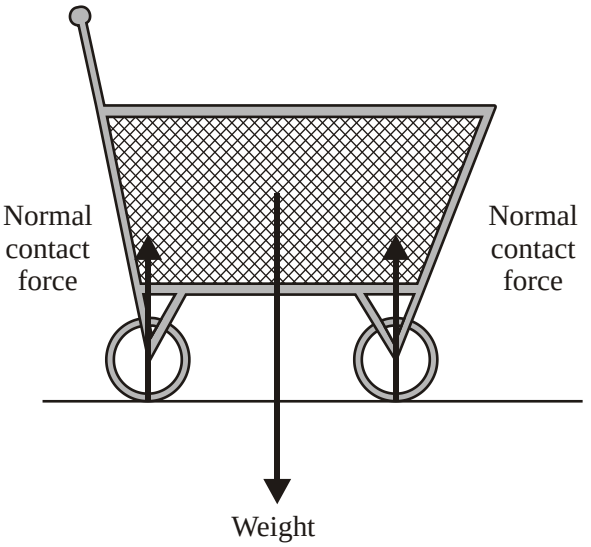
(1)

(Total 7 marks)

22. (a) The diagram below shows the forces acting on a shopping trolley at rest.



(i) State Newton's first law of motion.

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(1)

(ii) In everyday situations, it does seem that a force is needed to keep an object, for example the shopping trolley, moving at constant speed in a straight line. Explain why.

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(1)

(iii) The vertical forces acting on the trolley are in equilibrium. Explain what **equilibrium** means.

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.....

(1)

(b) (i) The weight of the trolley is one of a Newton's third law force pair. Identify what the other force in this pair acts upon and what type of force it is.

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(2)

(ii) Give two reasons why the two normal contact forces do **not** form a Newton's third law pair.

1 .....

.....

2 .....

.....

(2)

(Total 7 marks)

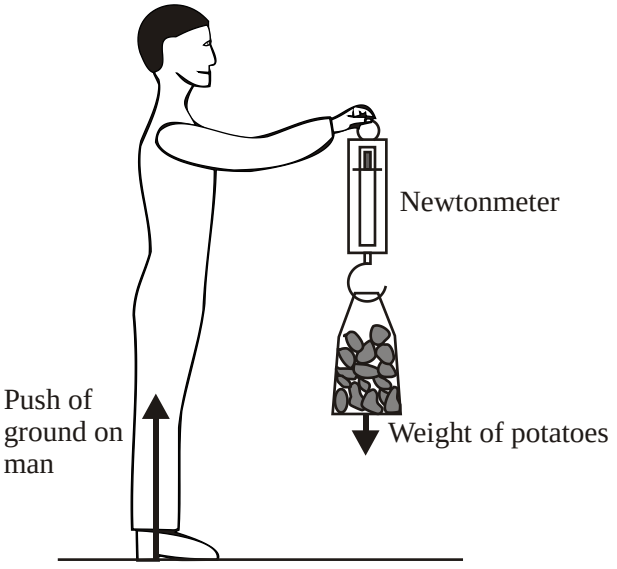
23. (a) Complete the following statement of Newton's third law of motion.

"If body A exerts a force on body B, then body B .....

....."

(2)

(b) A man checks the weight of a bag of potatoes with a newtonmeter. Two of the forces acting are shown in the diagram.



The table below gives these forces. For each force there is a corresponding force, the 'Newton's third law pair force'. In each case state

- the body that the Newton's third law pair force acts upon
- the type of force (one has been done for you)
- the direction of the Newton's third law pair force.

Force	Body the Newton's third law pair force acts upon	Type of force	Direction of the Newton's third law pair force
Weight of potatoes			
Push of ground on man		Normal contact force	

(3)
(Total 5 marks)