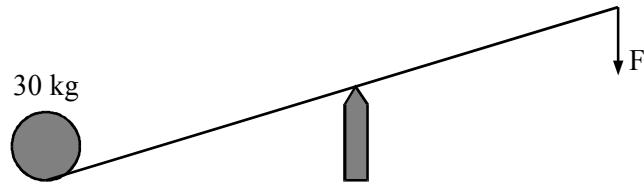


1. The diagram shows a lever with two arms of equal length and with a 30 kg mass at one end. The force F is just strong enough to raise the 30 kg mass off the ground.



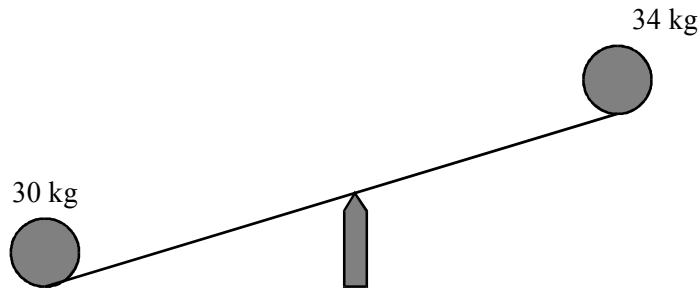
Calculate the magnitude of the force F .

.....

 $F =$

(2)

Instead of applying the force F to the far end of the lever, a 34 kg mass is placed there.

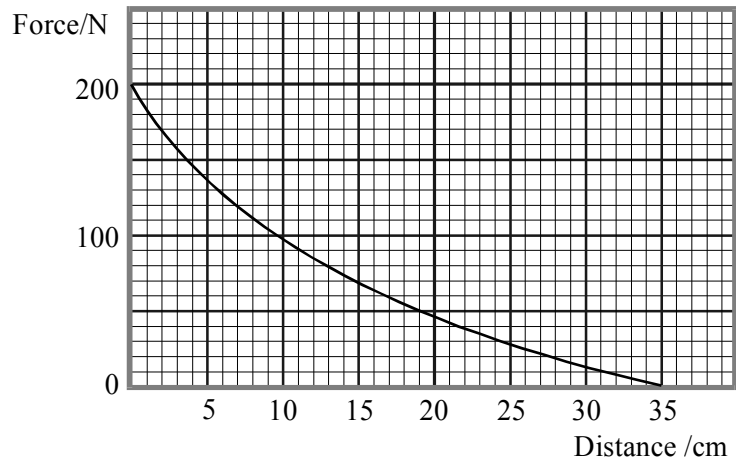


Draw on the diagram above, the forces acting on the 34 kg mass. Explain why it accelerates downwards.

.....

(4)
 (Total 6 marks)

2. A catapult fires an 80 g stone horizontally. The graph shows how the force on the stone varies with distance through which the stone is being accelerated horizontally from rest.



Use the graph to estimate the work done on the stone by the catapult.

.....

Work done =

(4)

Calculate the speed with which the stone leaves the catapult.

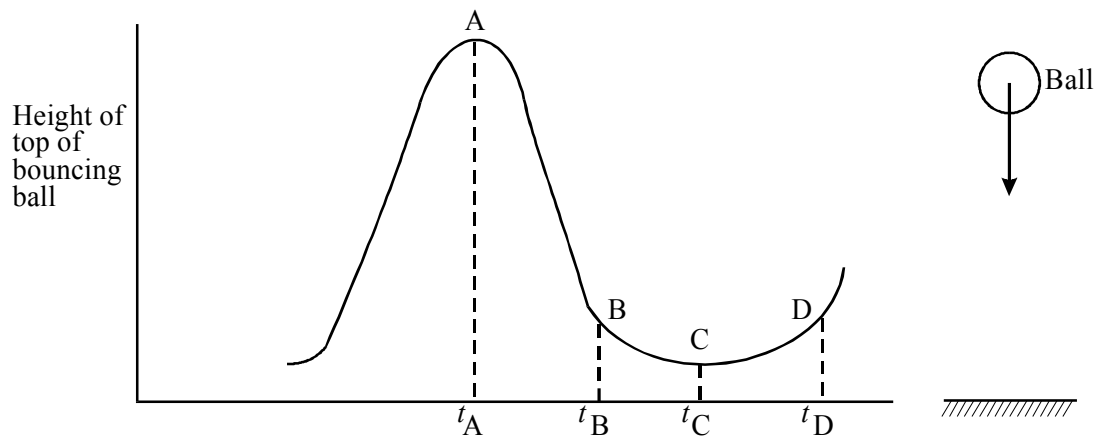
.....

Speed =

(2)

(Total 6 marks)

3. The graph shows how the height above the ground of the top of a soft bouncing ball varies with time.



Describe briefly the principal energy changes which occur between the times

t_A and t_B

.....
.....

(2)

t_A and t_C

.....
.....

(3)

t_C and t_D

.....
.....

(1)

(Total 6 marks)

4. Explain how a body moving at constant speed can be accelerating.

.....
.....
.....
.....
.....

(3)

The Moon moves in a circular orbit around the Earth. The Earth provides the force which causes the Moon to accelerate. In what direction does this force act?

.....

(1)

There is a force which forms a Newton's third law pair with this force on the Moon. On what body does this force act and in what direction?

.....
.....

(2)

(Total 6 marks)

5. Draw a labelled diagram of the apparatus you would use to measure the acceleration of a body in free fall.

(3)

List the measurements you would make and show how you would use them to calculate the acceleration.

.....

.....

.....

.....

.....

.....

.....

(5)
(Total 8 marks)

6. State Newton's second law of motion.

.....

.....

.....

.....

(2)

A student says, incorrectly, "Momentum is conserved completely in elastic collision, but not in inelastic collisions." Rewrite this sentence to make a correct statement about momentum conservation.

.....

(1)

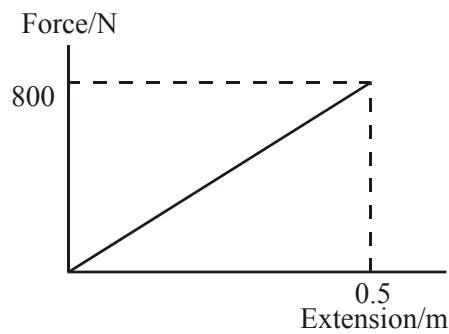
In what circumstance is kinetic energy conserved in a collision?

.....

(1)

(Total 4 marks)

7. At the battle of Agincourt in 1415, the English archers overcame a much stronger French army by shooting arrows from longbows which required a maximum force of about 800N to draw the string back a distance of half a metre. The graph shows the force-extension graph for a helical spring stretched elastically throughout his distance by this force.



Calculate the energy stored in the spring for an extension of half a metre.

.....

Energy =

(2)

The arrows used at Agincourt were able to penetrate light armour and had a mass of about 60 g. Use your calculated value of energy to find an approximate value for the speed at which the arrow would leave the bow.

.....

(3)

In practice, the energy stored in the drawn bow is more than that stored in the helical spring stretched the same amount by the same force. Sketch, on the axes bow, a possible force-extension graph for this bow.

(2)

The arrows were fired upwards at an angle of 45° to the horizontal. Describe and explain what happens during the flight to the

(i) horizontal velocity component

.....
.....
.....

(2)

(ii) vertical velocity component.

.....
.....
.....
.....

(3)

(Total 12 marks)

8. Describe, with the aid of a diagram, how you would measure the acceleration of free fall by a method involving the use of a freely-falling body.

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.....
.....

(6)

Identify and explain one precaution you would take to minimise the errors in your experiment.

.....
.....
.....

(2)
(Total 8 marks)

9. An athlete of mass 55 kg runs up a flight of stairs of vertical height 3.6 m in 1.8 s. Calculate the power that this athlete develops in raising his mass.

.....
.....
.....
.....

Power =

(3)

One way of comparing athletes of different sizes is to compare their power-to-weight ratios. Find a unit for the power-to-weight ratio in terms of SI base units.

.....
.....
.....
.....

(2)

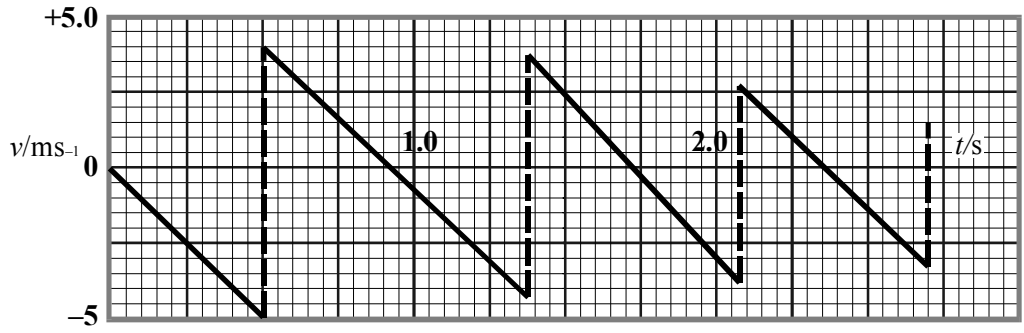
Calculate the athlete's power-to-weight ratio.

.....
.....

Power-to-weight ratio =

(2)
(Total 7 marks)

10. The diagram shows a velocity-time graph for a ball bouncing vertically on a hard surface.



At what instant does the graph show the ball to be in contact with the ground for the third time?

..... (2)

The downwards-sloping lines on the graph are straight. Why are they straight?

.....

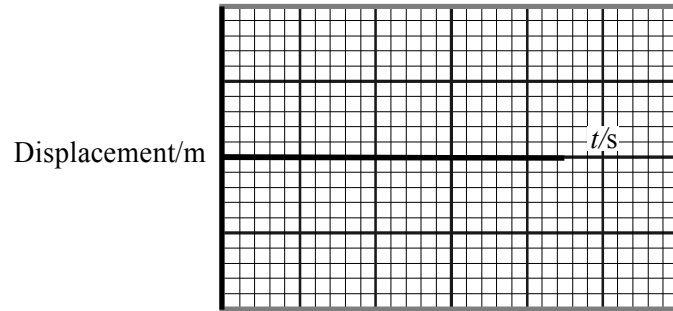
 (2)

Calculate the height from which the ball is dropped.

.....

 Height = (3)

Sketch a displacement-time curve on the axes below for the first second of the motion.



(3)

What is the displacement of the ball when it finally comes to rest?

.....

(1)

(Total 11 marks)

11. Describe an experiment you would perform to provide a *single* illustration of the principle of conservation of linear momentum.

(i) Sketch and label a diagram of the apparatus you would use.

(2)

(ii) List the physical quantities you would measure and state how you would measure them.

.....
.....
.....
.....
.....
.....
.....
.....

(4)

(iii) How would you use this information to provide a single illustration of the law

.....
.....
.....
.....

(2)
(Total 8 marks)

12. An artery has a cylindrical cross-section of diameter 8 mm. Blood flows through the artery at an average speed of 0.3 m s^{-1} .

Calculate the average mass of blood flowing per second through the artery.

Density of blood at body temperature, $37 \text{ }^\circ\text{C} = 1060 \text{ kg m}^{-3}$.

.....
.....
.....
.....

Mass of blood =

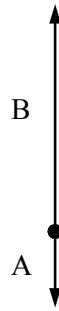
(5)

How would you verify experimentally the value of the density of blood quoted above, given a sample of volume approximately 5 cm^3 ?

.....
.....
.....
.....
.....
.....

(3)
(Total 8 marks)

13. The free-body force diagram shows the two principal forces which act on a parachutist at the instant of first contact with the ground.



What does the force A represent?

..... (1)

What does the force B represent?

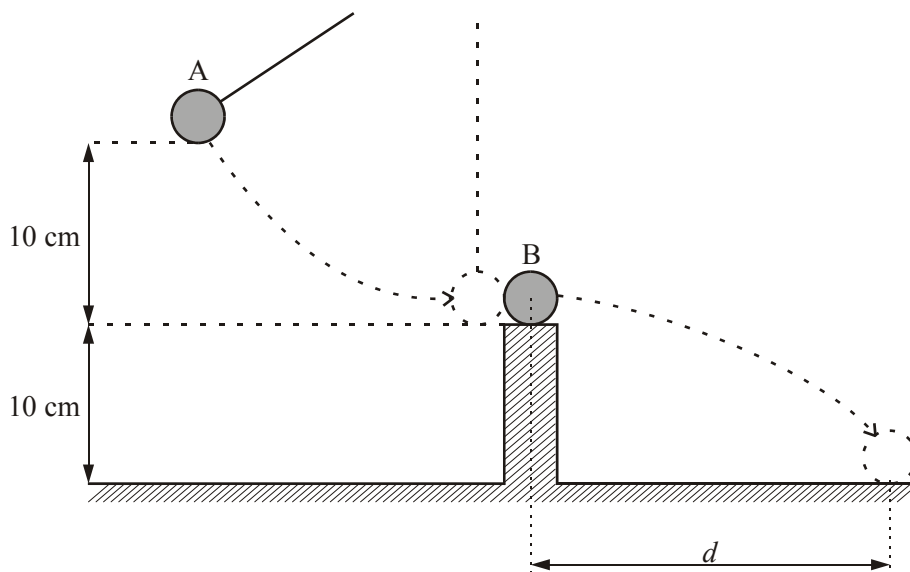
..... (1)

Why are these forces not equal?

.....

(2)
 (Total 4 marks)

14. The diagram illustrates an elastic collision between two spheres, A and B, of equal mass.



Sphere A is tied to the end of a long vertical thread and pulled to one side until it has risen a distance of 10 cm. It is then released and comes to rest when it strikes the sphere B which is resting on a smooth flat support.

Sphere B travels a horizontal distance d before it hits the ground after falling 10 cm.

Calculate the speed of A as it strikes B.

.....
.....
.....
.....

Speed = (4)

How long does B take to fall 10cm?

.....
.....
.....

Time= (3)

What is the speed of B just after the collision?

.....

(1)

Calculate the distance d

.....
.....

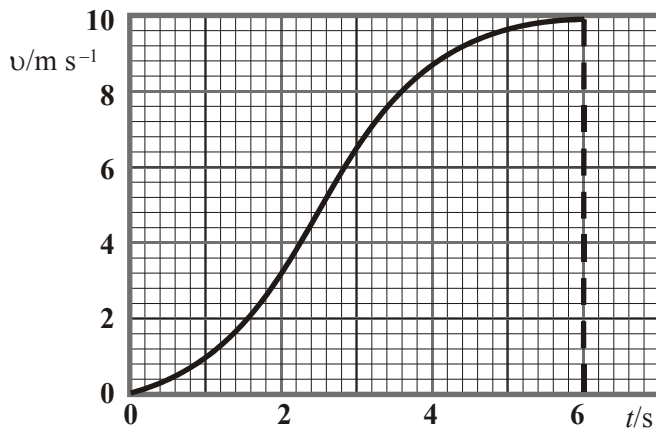
Distance = (2)

Explain briefly why B drops a distance of 10 cm much more quickly than A.

.....
.....
.....
.....

(2)
(Total 12 marks)

15. The graph shows the horizontal speed v of a long jumper from the start of his run to the time when he reaches the take-off board.



Use the graph to estimate his maximum acceleration.

.....

Acceleration =

(3)

Use the graph to estimate the distance of the 'run-up'.

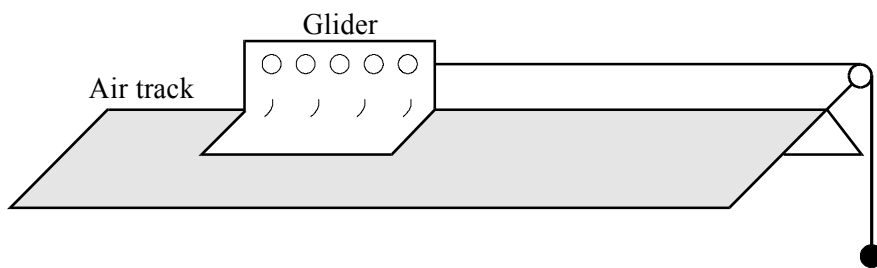
.....

Distance =

(2)

(Total 5 marks)

16. The diagram shows a mass attached by a piece of string to a glider which is free to glide along an air track.



A student finds that the glider takes 1.13 s to move a distance of 90 cm starting from rest.

Calculate the speed of the glider after 1.13 s.

.....
.....
.....
.....

Speed =

(4)

Calculate its average acceleration during this time.

.....
.....
.....

Average acceleration =

(3)

How would you test whether or not the acceleration of the glider is constant?

.....
.....
.....
.....
.....
.....

(3)

(Total 10 marks)

17. A mass is oscillating vertically on the end of a spring. Explain what happens to the following quantities as the mass rises from the bottom of its motion to the top.

Kinetic energy

.....
.....
.....

Gravitational potential energy

.....
.....
.....

Elastic potential energy

.....
.....
.....

(4)

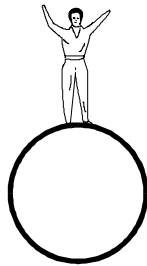
After a long time, the mass stops oscillating. What has happened to the energy?

.....
.....
.....

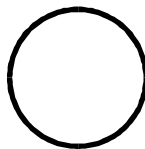
(2)

(Total 6 marks)

18. The diagram shows a man standing on a planet.



Complete and label two free-body force diagrams in the space below, one for the man and one for the planet.



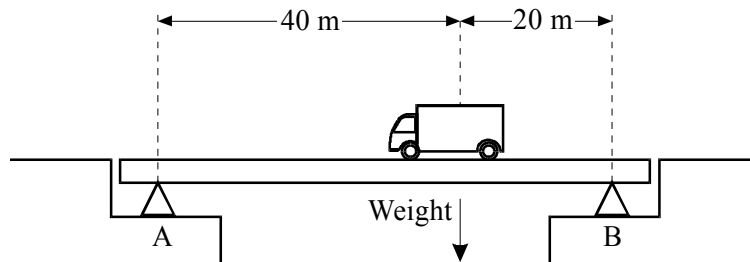
(4)

The man is in equilibrium. Explain what can be deduced about the forces acting on the man.

.....
.....

(1)
(Total 5 marks)

19. The diagram shows a lorry on a bridge.



The total mass of the lorry is 45 000 kg. Calculate its weight.

.....
.....
.....

Weight =

(1)

By taking moments about A, find the increase in the upward force provided by support B when the lorry is on the bridge and in the position shown in the diagram.

.....
.....
.....
.....

Increase =

(2)

Calculate the corresponding increase in the force provided by support A.

.....
.....
.....
.....

Increase =

(1)
(Total 4 marks)

20. State Newton's second law of motion.

.....
.....
.....

(2)

You are asked to test the relation between force and acceleration.

Draw and label a diagram of the apparatus you would use.

State clearly how you would use the apparatus and what measurements you would make.

.....
.....
.....
.....

(6)

Explain how you would use your measurements to test the relationship between force and acceleration.

.....
.....
.....
.....
.....

(3)
(Total 11 marks)

21. The “engine” of a hang-glider is the gravitational field of the Earth. Hang-gliders drop slowly through the air during their flight. The weight of a reasonably efficient hang-glider, including the pilot, is about 900N. When the forward flight speed has a steady value of 18 ms^{-1} , the sinking speed is approximately 1.2 m s^{-1} .

Calculate the decrease in potential energy per second.

.....
.....

Decrease =

Explain what happens to this potential energy.

.....
.....
.....
.....

(4)

The maximum steady power output of a fit racing cyclist over several hours is about 400 W. Explain why sustained man-powered flight is difficult to achieve.

.....
.....
.....
.....

(2)
(Total 6 marks)

22. Write down a word equation which defines the magnitude of a force.

.....
.....
.....
.....

(2)

Two forces have equal magnitudes. State three ways in which these two equal forces can differ.

.....
.....
.....
.....

(3)

(Total 5 marks)

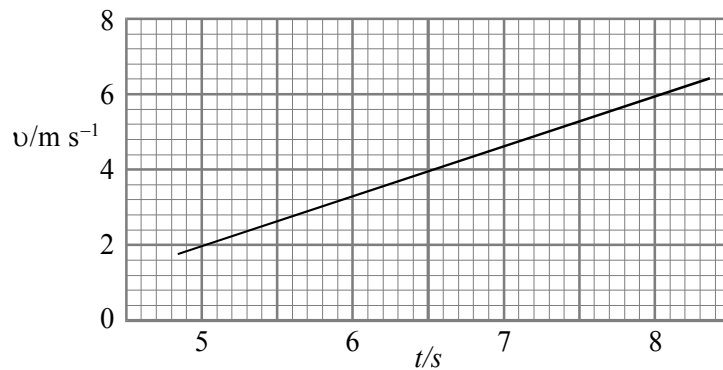
23. Demonstrate that the following equation is homogeneous with respect to units. The symbols have their usual meanings.

$$x = ut + \frac{1}{2}at^2$$

.....
.....
.....
.....

(2)

The following graph shows the speed v of a body during a time interval of just 3 seconds.



Use the graph to determine the magnitude of the acceleration a .

.....
.....
.....

(3)

Find the distance travelled by the body between $t = 6$ s and $t = 8$ s..

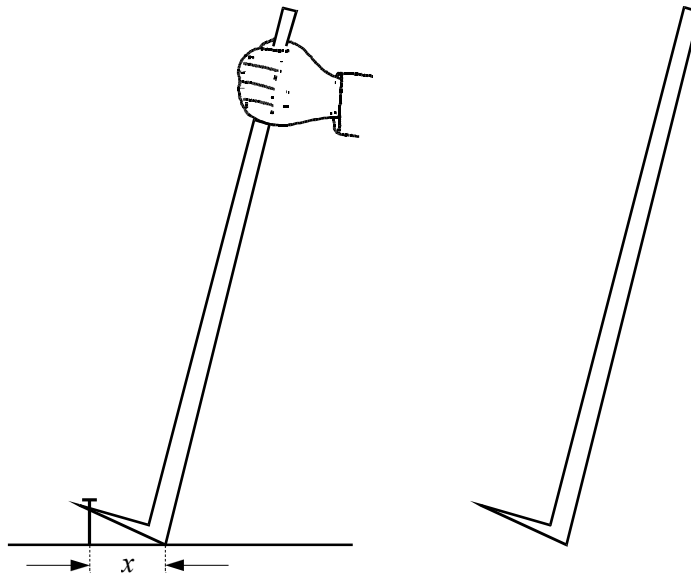
.....
.....

Distance =

(2)

(Total 7 marks)

24. The diagram on the left shows a crowbar being used to pull a nail out of a wooden floor.



Use the diagram on the right to draw and to label a free-body force diagram for the crowbar. For each of the four forces which act on the crowbar, show the line of action, the direction and the source.

(4)

Identify one of the above forces which is not involved in an energy transfer process. Explain your answer.

.....
.....
.....

(2)

Give one advantage and one disadvantage of keeping the distance x as small as possible.

Advantage

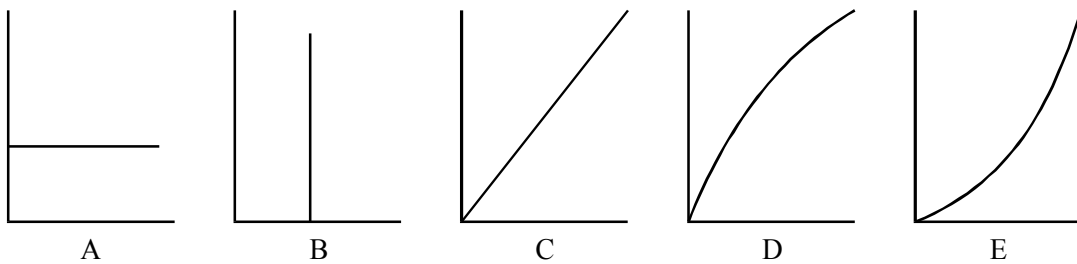
.....

Disadvantage

.....

(2)
(Total 8 marks)

25. Each of the following graphs can be used to describe the motion of a body falling from rest. (Air resistance may be neglected.)



Which graph shows how the kinetic energy of the body (y -axis) varies with the distance fallen (x -axis)?

Graph

Explain your answer.

.....

.....

.....

(3)

Which graph shows how the distance fallen (y -axis) varies with the time (x -axis)?

Graph

Explain your answer.

.....

.....

.....

(3)

Which graph shows the relationship between acceleration (y -axis) and distance (x -axis)?

Graph

Explain your answer.

.....
.....
.....

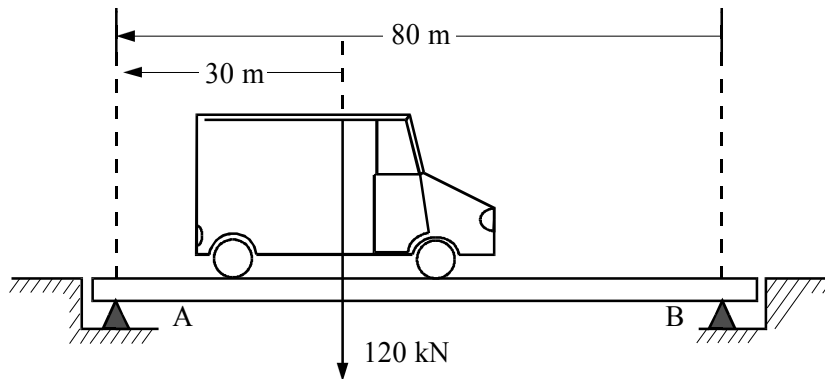
(3)
(Total 9 marks)

26. State the principle of moments.

.....
.....
.....

(2)

The diagram shows a lorry on a light bridge.



Calculate the downwards force on each of the bridge supports.

.....
.....

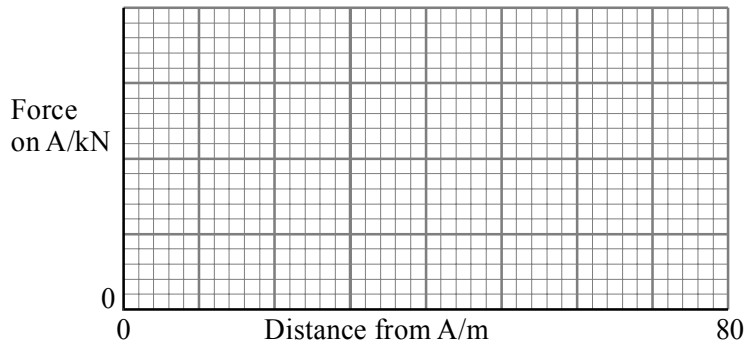
Force at A =

.....
.....

Force at B =

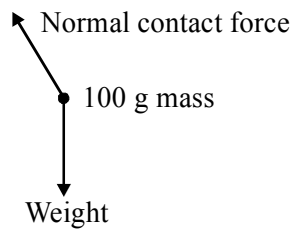
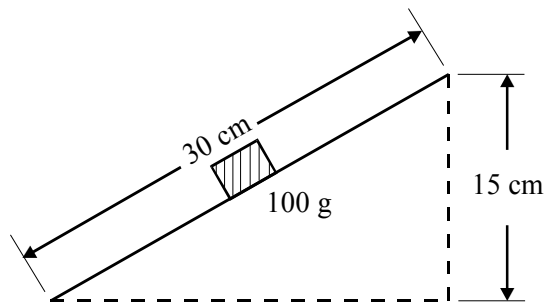
(4)

Sketch a graph on the axes below to show how the force on the support at A changes as the centre of gravity of the lorry moves from A to B. Mark the value of the intercept on the force axis.



(3)
(Total 9 marks)

27. The diagram shows a smooth wooden board 30 cm long. One end is raised 15 cm above the other. A 100 g mass is placed on the board. The two forces acting on the 100 g mass are shown on the free-body force diagram.



Explain with the aid of a sketch why the resultant force on the 100 g mass acts parallel to the board and downwards.

.....

.....

.....

.....

(2)

Calculate the magnitude of this resultant force.

.....
.....

Magnitude =

(2)

Calculate the kinetic energy gained by the 100 g mass as it slides down 20 cm of the slope.

.....
.....
.....

Kinetic energy =

(2)

The smooth board is replaced by a similar rough board which exerts a frictional force of 0.19 N on the 100 g mass. Calculate the new value for the kinetic energy gained by the 100 g mass as it slides down 20 cm of slope.

.....
.....
.....

Kinetic energy =

(2)

Explain why the final kinetic energy of the 100 g mass is greater when the board is smooth.

.....
.....
.....
.....

(2)

(Total 10 marks)

28. A ball rolls over an obstacle which has been placed on a flat horizontal surface. The diagrams opposite show a velocity-time graph, a displacement-time graph and the axes for an acceleration-time graph for the horizontal motion of the ball. The time axes for the three graphs are identical.

Calculate the changes of displacement during the time intervals (i) $t = 0$ to $t = X$ and (ii) $t = X$ to $t = Y$.

(i)
 Change of displacement during time interval $0X =$

(ii)
 Change of displacement during time interval $XY =$

(3)

Add in the scale values for the displacement axis on the second graph.

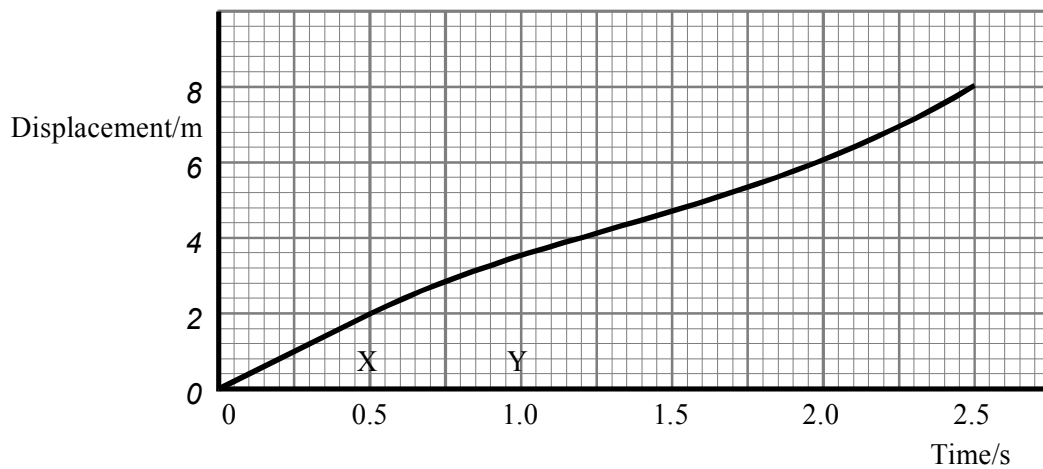
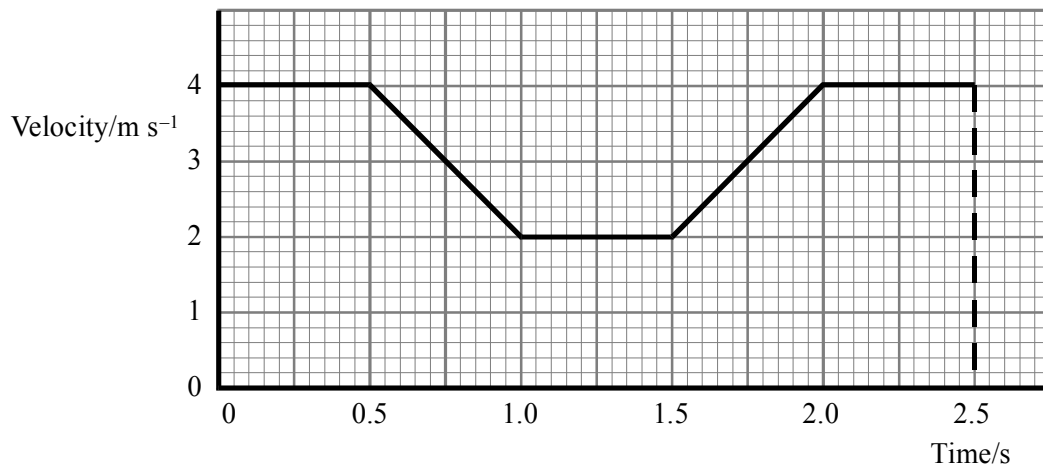
(1)

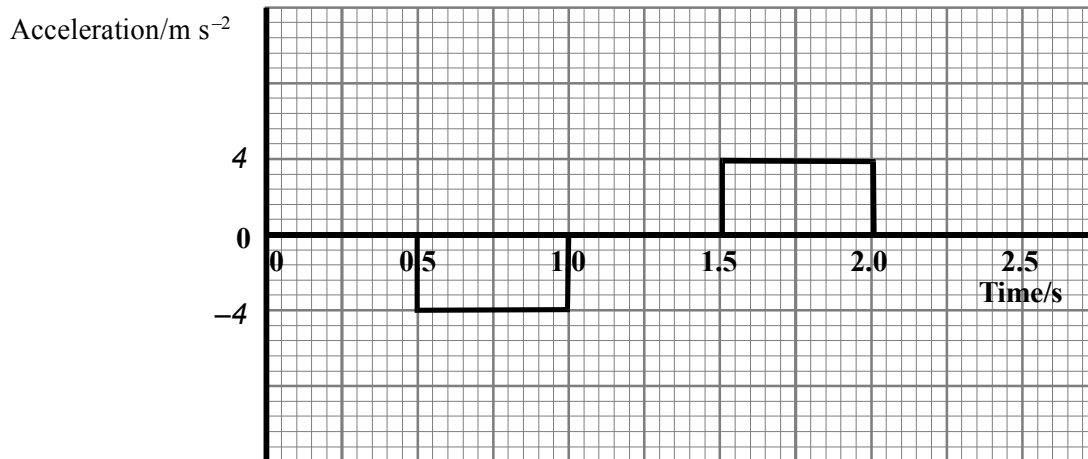
Sketch the acceleration-time graph and add the scale values to the acceleration axis.

(4)

Sketch the shape of a vertical cross-section of the obstacle (without showing any of the dimensions) in the space below.

(2)





(Total 10 marks)

29. State the difference between scalar and vector quantities.

.....

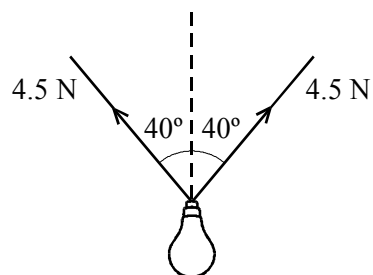
.....

.....

.....

(2)

A lamp is suspended from two wires as shown in the diagram. The tension in each wire is 4.5 N.



Calculate the magnitude of the resultant force exerted on the lamp by the wires.

.....

.....

.....

(3)

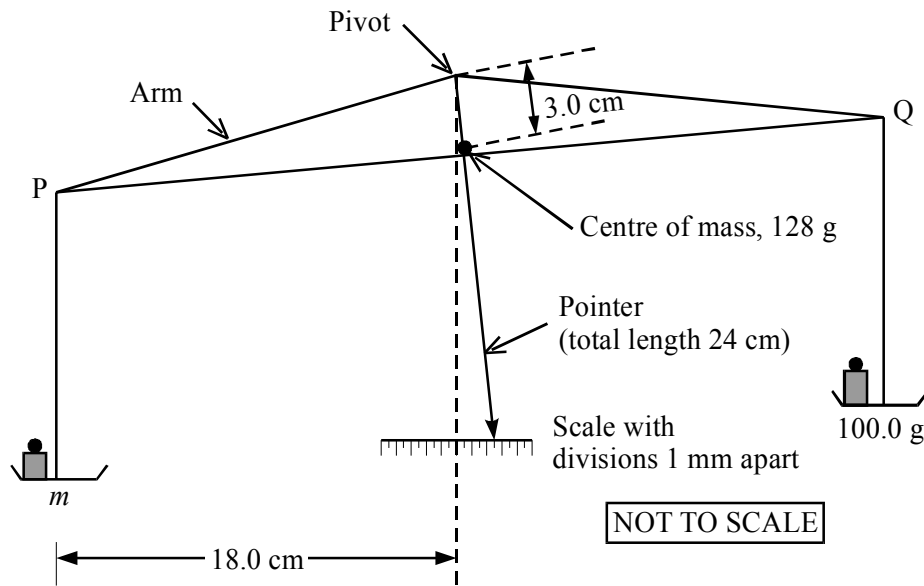
What is the weight of the lamp? Explain your answer.

.....

.....

(2)
(Total 7 marks)

30. The diagram shows an old-style chemical balance. The total mass of the moving part (i.e arm, pointer and two scale pans) is 128 g and when the pointer is vertical the centre of mass is 3.0 cm vertically below the pivot.



The pointer, which is 24.0 cm long, moves over a scale whose divisions are 1.0 mm apart. The pointer is deflected five scale divisions to the right.

Show that the horizontal displacement of the centre of mass is 0.625 mm.

.....

.....

.....

.....

(3)

The mass in the right-hand scale pan is 100.0 g. Assume that the horizontal distance of P and Q from the pivot are constant. Calculate the mass m in the left-hand scale pan.

.....

.....

.....

.....

Mass $m =$

(3)

Explain why the scale over which the pointer moves is not calibrated.

.....

.....

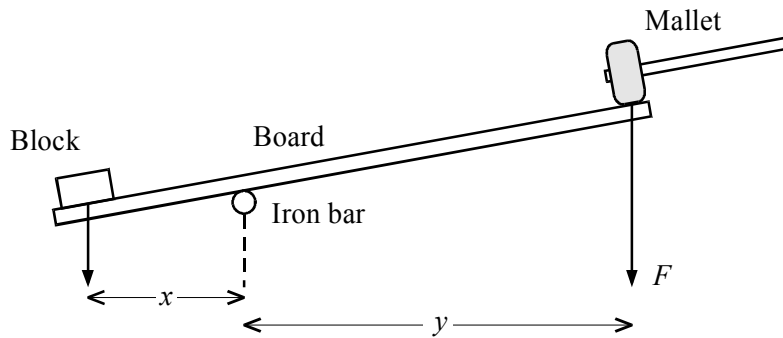
.....

.....

(2)

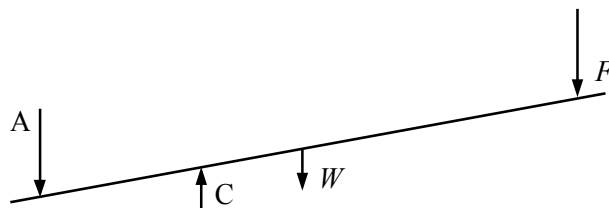
(Total 8 marks)

31. The diagram shows a flat wooden board resting on an iron bar and with a heavy block resting on the left hand end of the board.



The block is thrown into the air when the right hand end of the board is struck by a mallet.

The diagram below is the free-body force diagram for the wooden board *just after the block has begun to move*.



Four forces are shown on the free-body force diagram. W is the weight of the board and A is the downward push on the board from the block. State whether the magnitude of the force A is greater than, equal to or less than the weight of the block. Explain your answer.

.....

.....

.....

.....

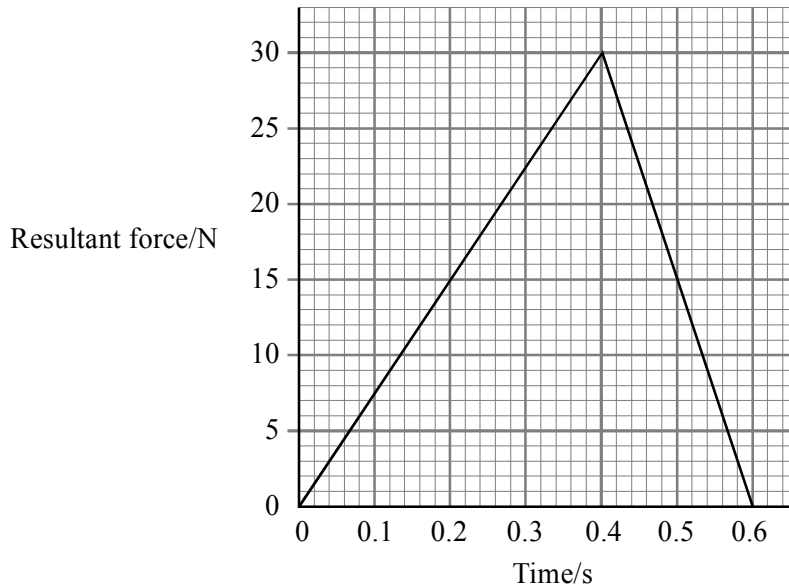
Write down suitable labels for the forces F and C .

Force F

Force C

(4)

The graph below shows how the resultant force on the block varies with time.



Use the graph to find a value for the impulse applied to the block

.....

.....

Impulse =

The mass of the block is 7.1 kg. Calculate its maximum upward speed.

.....

.....

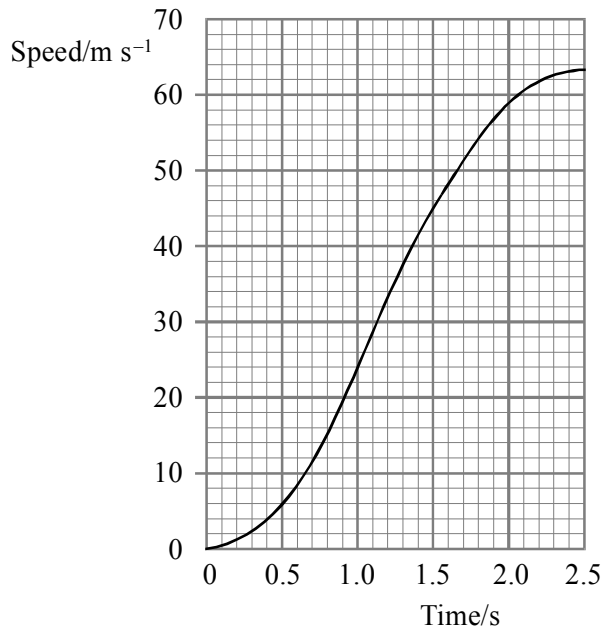
Speed =

The force of the board on the block is not equal to the resultant force on the block. Why not?

.....
.....
.....
.....
.....

(6)
(Total 10 marks)

32. The graph shows the speed of a racing car during the first 2.6 seconds of a race as it accelerates from rest along a straight line.



Use the graph to estimate

- (i) the displacement 1.5 s after the start.

.....
.....
.....

Displacement =

(ii) the acceleration at 2.0 s

.....
.....
.....

Acceleration =

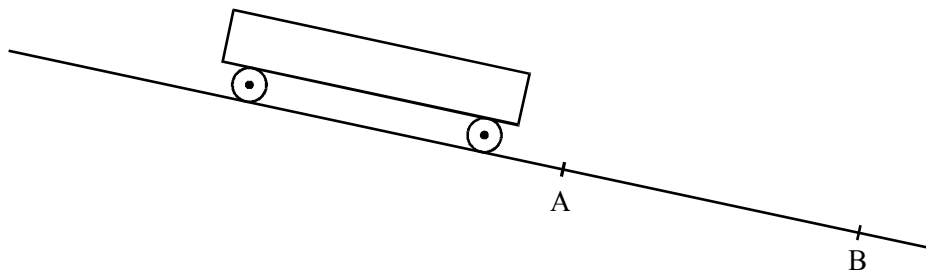
(iii) the kinetic energy after 2.5 s given that the mass of the racing car is 420 kg

.....
.....
.....

Kinetic energy =

(Total 6 marks)

33. The diagram shows a toy truck, about 30 cm long, accelerating freely down a gentle incline.



Explain carefully how you would measure the average speed with which the truck passes the point A.

.....
.....
.....
.....
.....
.....
.....
.....

(4)

You find that the measured average speed of the truck is 1.52 m s^{-1} when it passes the point A and 1.64 m s^{-1} when it passes the point B. The distance from A to B 1.20 m . Calculate the acceleration of the truck.

.....

.....

.....

.....

.....

.....

Acceleration =

(2)
(Total 6 marks)

34. Define the term *work*.

.....

.....

.....

.....

(2)

A particle is moving along a circular path at constant speed. *Use your definition of the term work* to explain why the resultant force acting on the particle must be acting at right angles to its path.

.....

.....

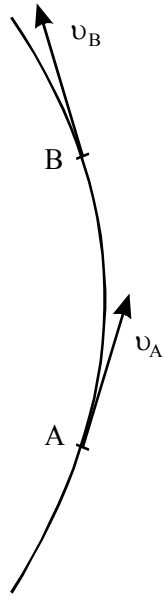
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.....

.....

(3)

The diagram shows the velocity vectors at two points along the circular path.



With reference to this diagram, explain briefly why the direction of the acceleration must be towards the centre of the circle.

.....

.....

.....

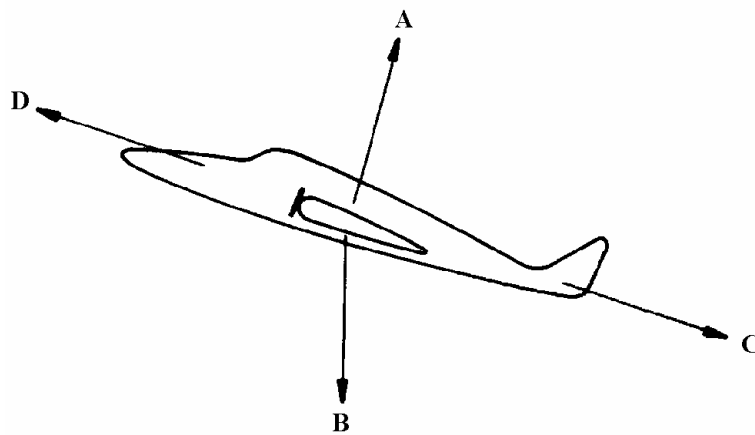
.....

.....

.....

(3)
(Total 8 marks)

35. The diagram shows a free-body force diagram for an aircraft flying along a straight path and climbing at constant speed.



Name each of the four forces shown and identify in each case what exerts the force.

Force A

.....

Force B

.....

Force C

.....

Force D

.....

(4)

State whether or not the resultant force is zero. Explain your answer.

.....

.....

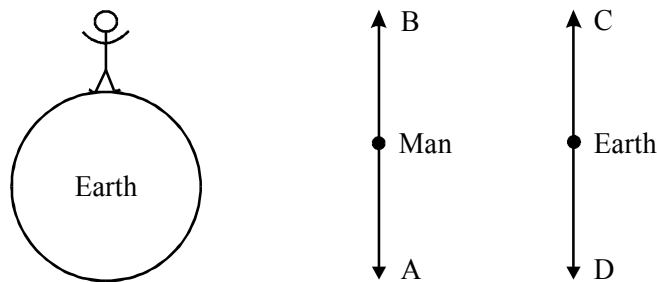
.....

.....

(2)

(Total 6 marks)

36. The diagrams show a man standing on the Earth and two free-body force diagrams, one for the man and one for the Earth.



Force A can be described as 'the Earth pulling the man down with a gravitational force'. Use a similar form of words to describe force C which forms a Newton third law pair with force A.

.....

.....

.....

(2)

Noting that forces A and C are a Newton third law pair, write down three similarities and two differences between these two forces.

Similarities:

- (i)
- (ii)
- (iii)

Differences:

- (i)
- (ii)

(5)

Which two forces show whether or not the man is in equilibrium?

.....

(1)

(Total 8 marks)

37. Twin engine aircraft use less fuel than those with four engines. Recent improvements in engine reliability mean that they are now considered safe for long commercial flights over water. An aircraft powered by two Rolls-Royce Trent engines demonstrated its endurance by flying nonstop round the world. During this flight it used 1.7×10^5 litres of aviation fuel.

Each litre of fuel releases 38 MJ when combined with oxygen in the air.

Calculate the total amount of energy released during the flight.

.....
.....
.....

Energy =

(2)

The flight lasted 47 hours. Calculate the average input power to the engines.

.....
.....

Power =

(2)

The distance covered by the aircraft was 41000 km. Calculate the aircraft's average speed.

.....
.....
.....

Speed =

The *maximum* thrust of each engine is 700 kN. Multiply the total maximum thrust by the average speed and comment on your answer.

.....
.....
.....
.....

(6)
(Total 10 marks)

- 38.** A careless soldier shoots a bullet vertically into the air at 450 m s^{-1} . Calculate the time the bullet takes to reach the top of its flight. State any assumption you have made.

.....
.....
.....
.....

Time

(3)

Sketch and label fully a velocity-time graph for the bullet's complete flight.

Explain the shape of your graph.

.....
.....
.....

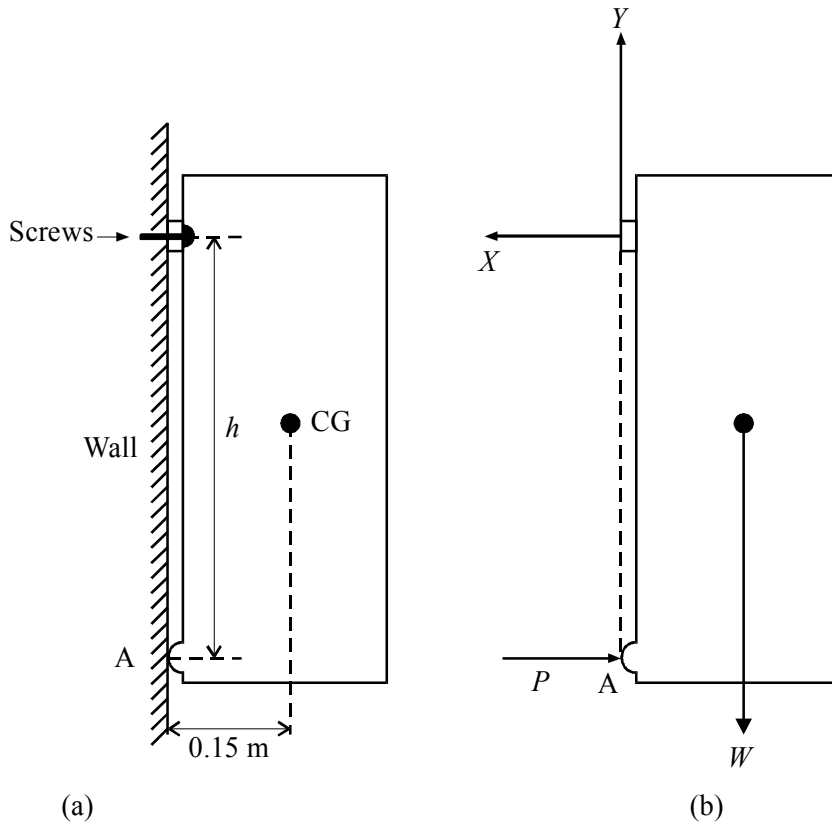
Use your graph to calculate the distance travelled by the bullet before it hits the ground.

.....
.....
.....

(7)
(Total 10 marks)

39. Diagram (a) shows a side view of a kitchen wall cupboard. Its lower edge rests against the wall at A. It is fastened by screws at a height h vertically above A. The mass of the cupboard is 10kg and its centre of gravity is 0.15 m from the wall.

Diagram (b) is a free-body force diagram for the cupboard.



State the magnitude of force Y .

..... (1)

Explain why forces X and P must have equal magnitude.

.....
 (1)

Calculate the moment of the weight of the cupboard about point A.

.....

 Moment = (2)

Calculate the value of force X when $h = 0.06$ m

.....

Force $X =$

(2)

In principle the fixing screws could be positioned anywhere between point A and the top of the cupboard. Sketch a graph to show how the size of force X would depend on h for values of h from zero up to 0.60m.

(2)

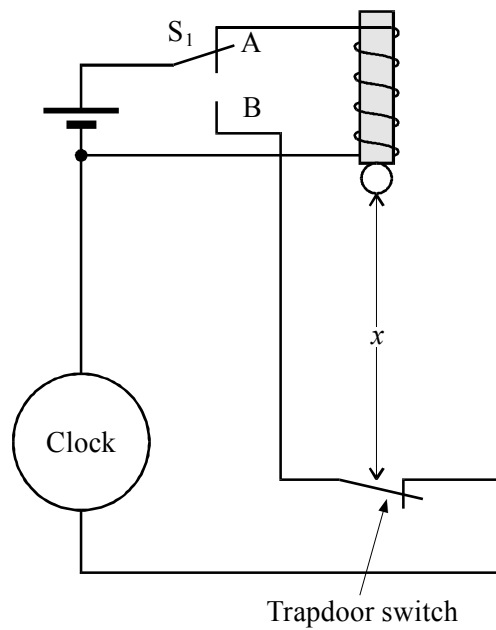
Explain why in practice the screws are usually situated as high in the cupboard as possible.

.....

(2)

(Total 10 marks)

40. The diagram shows an apparatus for timing a falling ball.



State what happens at the instant when the switch S_1 is moved from A to B.

.....
.....
.....
.....

(2)

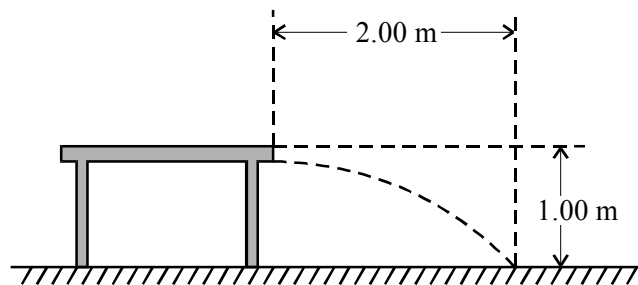
The distance x is 1.00 m. Calculate the time for the ball to fall this distance.

.....
.....
.....
.....

Time =

(3 marks)

In a second experiment the ball is fired horizontally from the edge of a table 1.00 m high.



State with a reason the time for the ball to reach the ground.

.....
.....

(2)

The ball hits the floor a horizontal distance of 2.00 m from the edge of the table. Calculate the speed at which the ball was fired.

.....
.....

Speed =

(2)

(Total 9 marks)

41. According to Newton's second law of motion, the rate of change of momentum of an object is

proportional to the resultant force F acting on it. Show how this statement leads to the equation

$$F = ma$$

where m is the mass and a the acceleration of the object.

.....

.....

.....

.....

.....

(4)

When jumping from a height on to a hard surface, it is advisable to bend one's knees on landing.

How does bending the knees affect the time one takes to come to rest?

.....

.....

(1)

With reference to Newton's second law, explain why it is a good idea to bend one's knees.

.....

.....

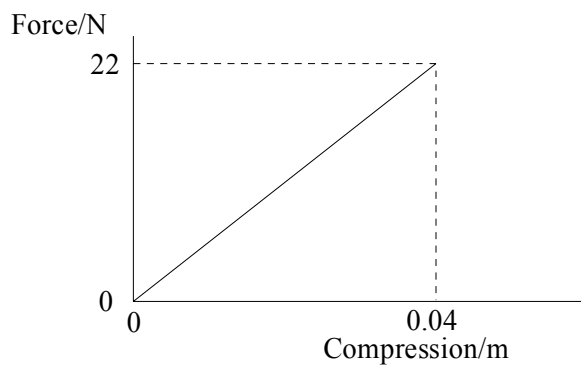
.....

.....

(2)

(Total 7 marks)

42. A toy frog has a spring which causes it to jump into the air. The force-compression graph for the spring is shown below.



Calculate the work done on the spring when it is compressed by 4.0 cm.

.....
.....
.....

Work done = (3)

The frog has a mass of 24 g and rises 0.60 m vertically into the air. Calculate the gravitational potential energy gained by the frog.

.....
.....
.....

Energy = (2)

Compare your two answers for energy and explain how they are consistent with the law of conservation of energy.

.....
.....
.....
.....

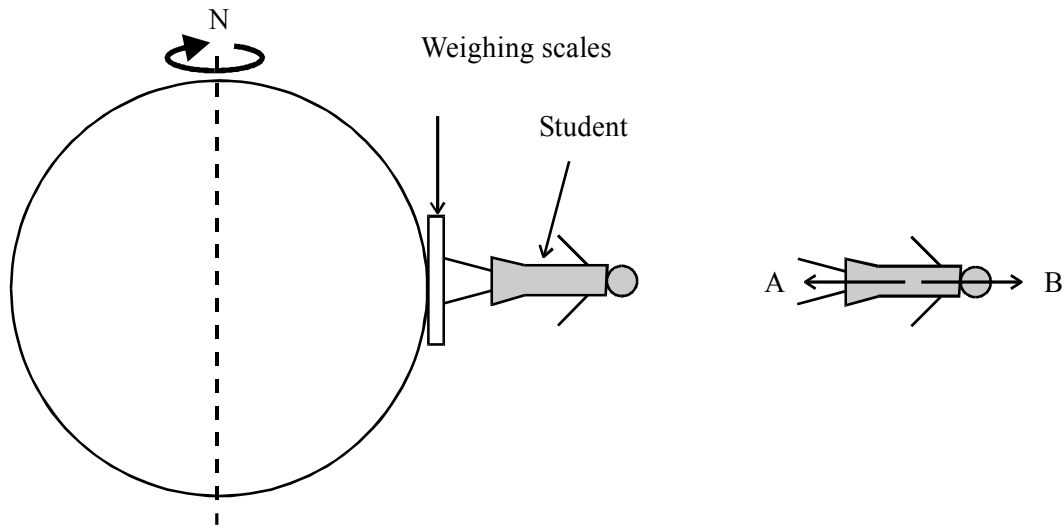
(2)
(Total 7 marks)

43. Explain why a body moving at constant speed in a circular path needs a resultant force acting on it.

.....
.....
.....
.....

(2)

The diagram shows a student at the equator standing on a set of weighing scales, and a free-body force diagram for the student.



Identify the bodies applying forces A and B.

.....

(2)

Because of the Earth's daily rotation the student is performing circular motion about the Earth's axis. Calculate the angular speed of the student.

.....

Angular speed =

(2)

The radius of the Earth is 6400 km. The student's mass is 55 kg. Calculate the resultant force on the student.

.....

Resultant force =

(3)

Force A is 539 N. Calculate the value of force B.

.....

Force B =

State, with a reason, the force indicated by the weighing scales.

.....
.....

(3)
(Total 12 marks)

44. The density of water is 1000 kg m^{-3} . How would you verify this value experimentally in a laboratory?

What other measurement ought to be quoted when a value for the density of a liquid is stated?

.....
.....
.....
.....
.....
.....

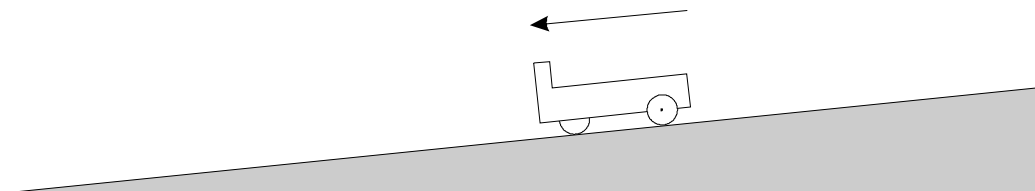
(4)

With reference to their molecular structures, explain why gases have very different densities from either solids or liquids.

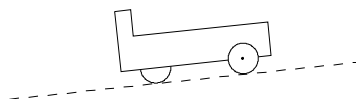
.....
.....
.....
.....

(2)
(Total 6 marks)

45. The diagram shows a trolley moving down a gentle slope.

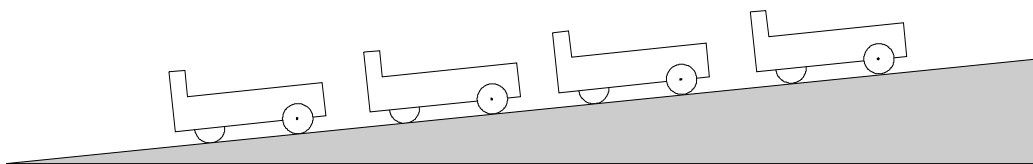


Add forces to the diagram below to produce a free-body force diagram for the trolley.



(3)

The trolley is photographed by a multiflash technique. The result is shown below.



What evidence is there that the trolley is moving with constant velocity?

.....

(1)

State the acceleration of the trolley down the slope.

.....

(1)

What does the value of the acceleration indicate about the forces acting on the trolley?

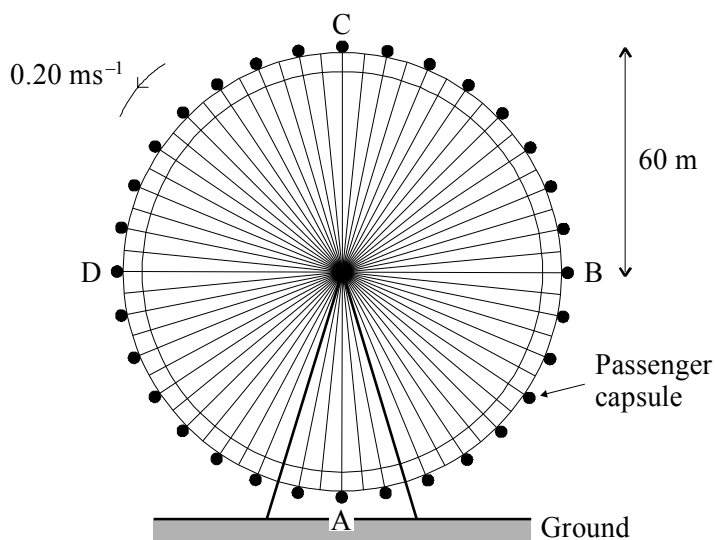
.....

(1)

(Total 6 marks)

46. 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.

.....
.....

Time =

(2)

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

.....
.....
.....
.....

(2)

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

.....
.....

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.

.....
.....
.....
.....

(2)
(Total 12 marks)

47. Define linear momentum.

.....
.....

(1)

The principle of conservation of linear momentum is a consequence of Newton's laws of motion. An examination candidate is asked to explain this, using a collision between two trolleys as an example. He gives the following answer, which is correct but incomplete. The lines of his answer are numbered on the left for reference.

1. During the collision the trolleys push each other.
2. These forces are of the same size but in opposite directions.
3. As a result, the momentum of one trolley must increase at the same rate as the momentum of the other decreases.
4. Therefore the total momentum of the two trolleys must remain constant.

In which line of his argument is the candidate using Newton's second law?

.....

(1)

In which line is he using Newton's third law?

.....

(1)

The student is making one important assumption which he has not stated. State this assumption. Explain at what point it comes into the argument.

.....
.....
.....
.....

(2)

Describe how you could check experimentally that momentum is conserved in a collision between two trolleys.

.....
.....
.....
.....

(4)

(Total 9 marks)

48. State the number of protons and the number of neutrons in ${}^{14}_6\text{C}$.

Number of protons =

Number of neutrons =

(2)

The mass of one nucleus of ${}^{14}_6\text{C} = 2.34 \times 10^{-26}$ kg.

The nucleus of carbon-14 has a radius of 2.70×10^{-15} m.

Show that the volume of a carbon-14 nucleus is about 8×10^{-44} m³.

.....
.....

(2)

Determine the density of this nucleus.

.....
.....
.....

Density =

(2)

How does your value compare with the densities of everyday materials?

.....

(1)

Carbon-14 is a radioisotope with a half-life of 5700 years. What is meant by the term half-life?

.....

.....

(2)

Calculate the decay constant of carbon-14 in s^{-1}

.....

.....

.....

.....

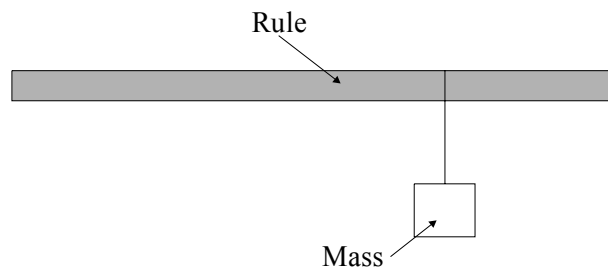
Decay constant s^{-1}

(2)

(Total 11 marks)

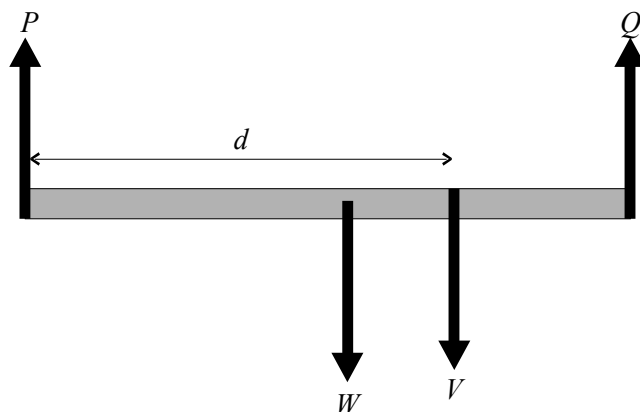
49. A student performs an experiment to investigate how the forces exerted on a bridge by its supports vary as a vehicle crosses the bridge. She models the bridge and vehicle using a metre rule and a suspended mass.

Complete and label the diagram below to show a way of supporting the ends of the rule so that the forces exerted on them can be measured.

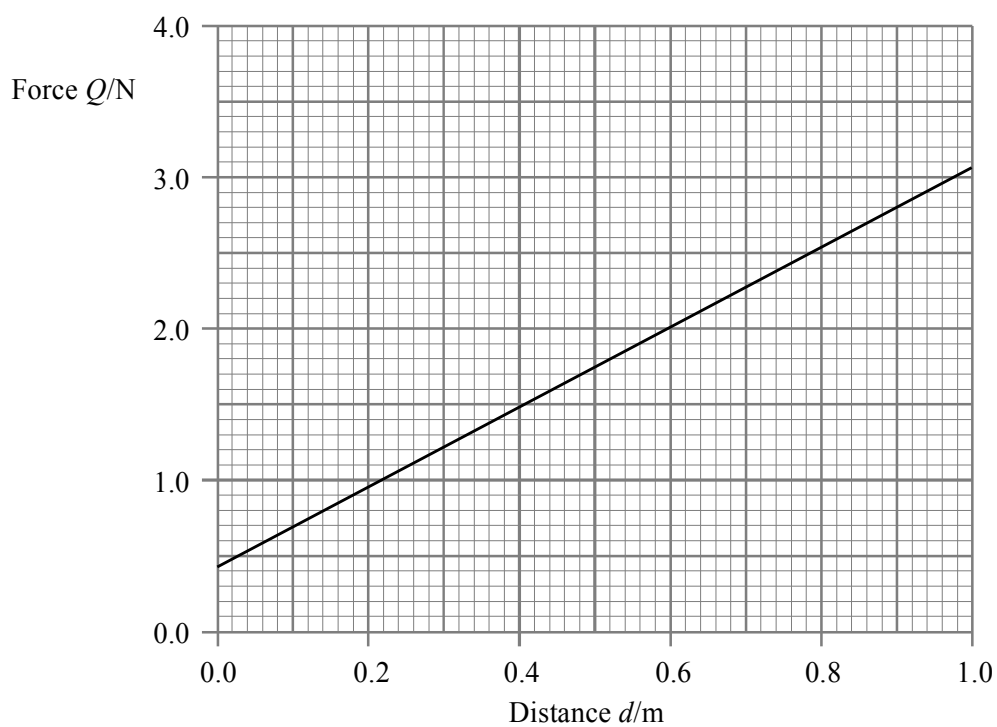


(2)

Below is a free-body force diagram for the rule. P and Q are the forces exerted by the supports; W and V are equal to the weights of the rule and suspended mass.



The graph shows how Q was found to vary with the position of the mass.



State the principle of moments.

.....

.....

.....

(2)

Use this principle to explain, without calculation, why force Q increases as distance d increases.

.....

.....

.....

.....

(2)

Using information from the graph, calculate the value of W .

.....

.....

.....

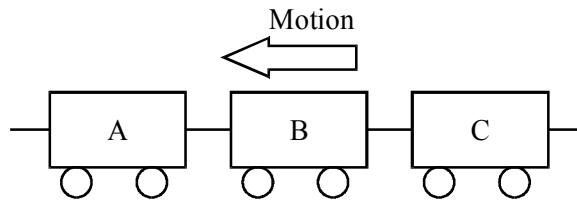
.....

$W =$

(3)

(Total 9 marks)

50. 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.

.....

.....

.....

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.

.....
.....
.....

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.

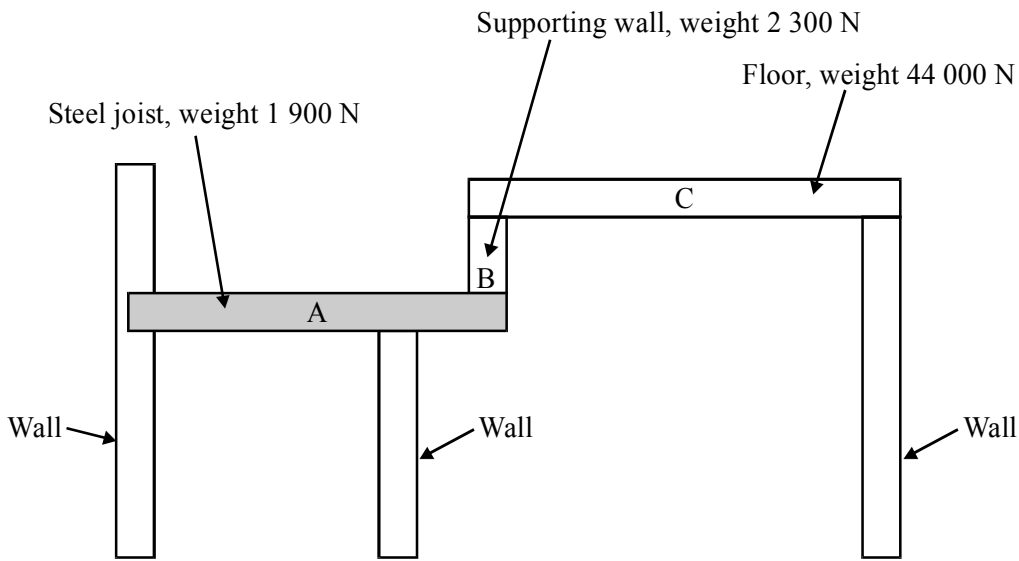
.....
.....
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Average current =

(2)

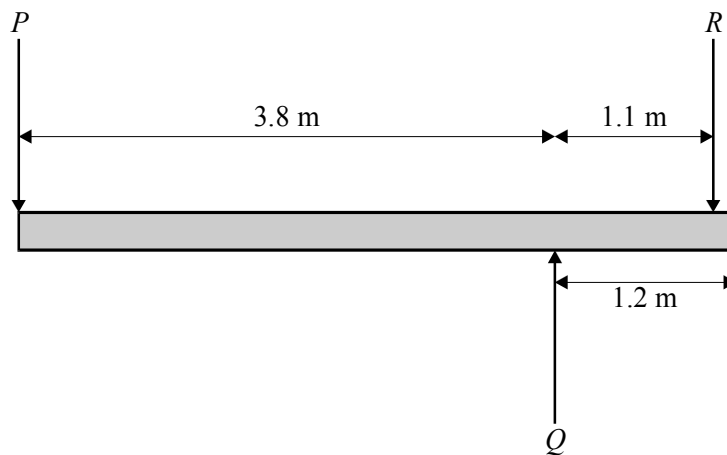
(Total 12 marks)

51. The diagram shows part of a steel and concrete building.



The steel joist A supports the supporting wall B and the left-hand side of floor C. Both the joist and floor C may be treated as uniform bars.

Below is an incomplete free-body force diagram for joist A.



Show that force R equals 24 300 N.

.....

(1)

Add the remaining force acting on joist A to the diagram, indicating its magnitude and the position where it acts.

(2)

Calculate the forces P and Q .

.....
.....
.....
.....
.....

Force P =

Force Q =

(3)
(Total 6 marks)

52. State the principle of conservation of linear momentum.

.....
.....
.....

(2)

This principle is a consequence of two of Newton's laws of motion. Which two?

.....

(1)

In one experiment to test the principle of conservation of momentum, a moving trolley collides with and sticks to an identical trolley which is initially at rest on a horizontal bench. Describe how you would check whether momentum was conserved.

.....
.....
.....
.....
.....
.....

(4)

A student performing this experiment found that the final momentum was always slightly smaller than the initial momentum. Assuming that the measuring technique was accurate, suggest a reason for this.

.....

(1)

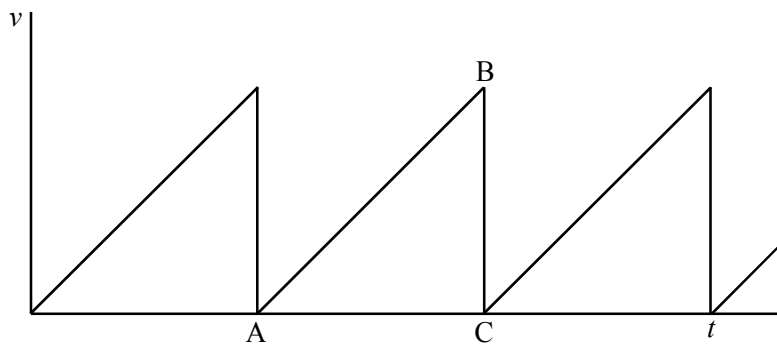
In a test laboratory, a car is crashed into a concrete wall and comes to rest. There is no damage to the wall. Explain how the principle of conservation of momentum applies to this situation.

.....

(2)

(Total 10 marks)

53. The diagram is a velocity-time graph for an electron.



Describe carefully the motion represented by lines AB and BC.

AB:

.....

BC:

.....

(2)

The graph is a much simplified model of how an electron moves along a wire carrying a current. Explain what causes the motion represented by AB and BC.

AB:

BC:

(2)

Explain the term *drift velocity* and indicate its value on the graph above.

.....

(2)

With reference to the behaviour of the electron, explain why the wire gets warm.

.....

(1)

(Total 7 marks)