Q1.

(a) The diagram shows a car travelling at a speed of 12 m/s along a straight road.

(i) Calculate the momentum of the car.

Mass of the car = 900 kg

Show clearly how you work out your answer.

Momentum = _______________ kg m/s

(ii) Momentum has direction.

Draw an arrow on the diagram to show the direction of the car’s momentum.

(b) The car stops at a set of traffic lights.

How much momentum does the car have when it is stopped at the traffic lights?

Give a reason for your answer.

Momentum = _______________ kg m/s

Q2.

The diagram shows the passenger train on part of a rollercoaster ride.

(a) Which arrow shows the direction of the resultant force acting on the passenger train?
(b) At the bottom of the slope, the passengers in the train all have the same speed but they each have a different kinetic energy.

Why is the kinetic energy of each passenger different?

___________________________________________________________________
___________________________________________________________________

(1)

(c) For part of the ride, the maximum gravitational field strength acting on the passengers seems 3 times bigger than normal.

Normal gravitational field strength = 9.8 N/kg

(i) Calculate the maximum gravitational field strength that seems to act on the passengers during the ride.

___________________________________________________________________
___________________________________________________________________

Maximum gravitational field strength = _______________ N/kg

(1)

(ii) One of the passengers has a mass of 80 kg.

Calculate the maximum weight this passenger seems to have during the ride.

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________

Maximum weight = _______________ N

(2)

(Total 5 marks)
In the first 2 seconds, the athlete accelerates constantly and reaches a speed of 9 m/s.

(i) Calculate the acceleration of the athlete.  

Show clearly how you work out your answer. 

____________________________________________________________________________ 
____________________________________________________________________________ 
____________________________________________________________________________  

Acceleration = _______________ 

(ii) Which one of the following is the unit for acceleration? 

Draw a ring around your answer. 

J/s  m/s  m/s²  Nm  

(1)

(iii) Complete the following sentence. 

The velocity of the athlete is the ____________________________ of the athlete in a given direction.  

(1)

(iv) Complete the graph to show how the velocity of the athlete changes during the first 2 seconds of the race.
Many running shoes have a cushioning system. This reduces the impact force on the athlete as the heel of the running shoe hits the ground.

The bar chart shows the maximum impact force for three different makes of running shoe used on three different types of surface.
(i) Which one of the three makes of running shoe, A, B or C, has the best cushioning system?

Explain the reason for your answer.

(ii) The data needed to draw the bar chart was obtained using a robotic athlete fitted with electronic sensors.

Why is this data likely to be more reliable than data obtained using human athletes?

Q4.

Part of a bus route is along a high street. The distance – time graph shows how far the bus travelled along the high street and how long it took.
(a) The bus travels the **slowest** between points **D** and **E**.

How can you tell this from the graph?

___________________________________________________________________
___________________________________________________________________

(1)

(b) Between which two points was the bus travelling the **fastest**?

Put a tick (✓) in the box next to your answer.

<table>
<thead>
<tr>
<th>Points</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A – B</td>
<td></td>
</tr>
<tr>
<td>B – C</td>
<td></td>
</tr>
<tr>
<td>C – D</td>
<td></td>
</tr>
</tbody>
</table>

(1)

(c) There is a bus stop in the high street. This is marked as point **B** on the graph.

(i) What is the distance between point **A** on the graph and the bus stop?

Distance _______________ metres

(1)

(ii) How long did the bus stop at the bus stop?
Show clearly how you work out your answer.

__________________________________________________________________________

Time = _______________ seconds

(2)

(d) A cyclist made the same journey along the high street.
The cyclist started at the same time as the bus and completed the journey in 200
seconds. The cyclist travelled the whole distance at a constant speed.

(i) Draw a line on the graph to show the cyclist’s journey.

(2)

(ii) After how many seconds did the cyclist overtake the bus?
The cyclist overtook the bus after _______________ seconds.

(1)

(Total 8 marks)

Q5.

The diagram shows an adult and a child pushing a loaded shopping trolley.

(a) (i) What is the total force on the trolley due to the adult and child?

__________________________________________________________________________

(1)

(ii) Which one of the terms in the box means the same as total force?

Draw a ring around your answer.

| answer force | mean force | resultant force |

(1)

(iii) The trolley is pushed at a constant speed for 80 metres.

Calculate the work done to push the trolley 80 metres.

Show clearly how you work out your answer.
Work done = ______________________________

(b) Complete the following sentences by drawing a ring around the correct word in each of the boxes.

(i) The unit of work done is the __________.
   - joule
   - newton
   - watt

(ii) Most of the work done to push the trolley is transformed into __________.
   - heat
   - light
   - sound

(Total 6 marks)

Q6.

(a) The diagram shows a steel ball-bearing falling through a tube of oil. The forces, L and M, act on the ball-bearing.

What causes force L?

(b) The distance – time graph represents the motion of the ball-bearing as it falls through the oil.
(i) Explain, in terms of the forces, \( L \) and \( M \), why the ball-bearing accelerates at first but then falls at constant speed.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(ii) What name is given to the constant speed reached by the falling ball-bearing?

________________________________________________________________________

(iii) Calculate the constant speed reached by the ball-bearing.

Show clearly how you use the graph to work out your answer.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Speed = ______________________________ m/s
Q7.

The diagram shows a motorbike of mass 300 kg being ridden along a straight road.

The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Kinetic energy lost = ______________________________ J

(b) (i) How much work is done on the motorbike by the braking force?

___________________________________________________________________

(ii) What happens to the kinetic energy lost by the motorbike?

___________________________________________________________________

(Question 8)

Q8.

(a) The diagram shows a child’s mobile. The mobile hangs from point P on the ceiling of the child’s bedroom.

(i) Mark the position of the centre of mass of the mobile by drawing a letter X on the diagram. Do this so that the centre of the X marks the centre of mass of the mobile.
(ii) Explain why you have chosen this position for your letter X.

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

(2)

(b) The diagram shows a device which helps to prevent a ladder from falling over.

Use the term *centre of mass* to explain why the ladder, in the situation shown, is unlikely to topple over. You may add to the diagram to illustrate your explanation.
Q9.
(a) The pictures show four objects. Each object has had its shape changed.

Bent metal ruler  A  Stretched bungee cords  B
Springs on a playground ride  C  Moulded plastic model car body  D

Which of the objects are storing elastic potential energy?

Explain the reason for your choice or choices.

(b) A student makes a simple spring balance. To make a scale, the student uses a range of weights. Each weight is put onto the spring and the position of the pointer
marked

The graph below shows how increasing the weight made the pointer move further.

(i) Which one of the following is the unit of weight?

Draw a ring around your answer.

- joule
- kilogram
- newton
- watt

(ii) What range of weights did the student use?

(iii) How far does the pointer move when 4 units of weight are on the spring?
(iv) The student ties a stone to the spring. The spring stretches 10 cm.

What is the weight of the stone?

(Q10. (Total 7 marks)

The diagram shows the horizontal forces acting on a car travelling along a straight road.

![Diagram of a car with force vectors labeled as Drag force and Driving force.]

(a) Complete the following sentences by drawing a ring around the correct word in each box.

(i) When the driving force equals the drag force, the speed of the car is

- decreasing
- constant
- increasing

(ii) Putting the brakes on transforms the car's kinetic energy mainly into

- heat
- light
- sound

(b) The charts, A, B and C give the thinking distance and the braking distance for a car driven under different conditions.

(i) Draw straight lines to match each chart to the correct conditions.

Draw only three lines.
Q11.

(a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.

(i) What is meant by the term *resultant force*?

(ii) Describe the movement of the aircraft when the resultant force is zero.
(b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Calculate the maximum acceleration of the aircraft.

Show clearly how you work out your answer and give the unit.

______________________________________________________________________________

______________________________________________________________________________

Acceleration = ________________________

(c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

(Total 7 marks)

Q12.

(a) The diagram shows a rectangle made out of a sheet of cardboard.

![Diagram of a rectangle](image)

Draw an X on the diagram so that the centre of the X is at the centre of mass of the rectangle.

(b) The drawing shows a car tyre.
Q13.

(a) A car driver makes an emergency stop.

The chart shows the ‘thinking distance’ and the ‘braking distance’ needed to stop the car.

<table>
<thead>
<tr>
<th>Thinking distance</th>
<th>Braking distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 m</td>
<td>38 m</td>
</tr>
</tbody>
</table>

Calculate the total stopping distance of the car.

Stopping distance = _________________________ m

(b) The graph shows how the braking distance of a car driven on a dry road changes with the car’s speed.
The braking distance of the car on an icy road is longer than the braking distance of the car on a dry road.

(i) Draw a new line on the graph to show how the braking distance of the car on an icy road changes with speed.

(ii) Which two of the following would also increase the braking distance of the car?

Put a tick (✓) next to each of your answers.

- rain on the road [ ]
- the driver having drunk alcohol [ ]
- car brakes in bad condition [ ]
- the driver having taken drugs [ ]

(c) The thinking distance depends on the driver’s reaction time.

The table shows the reaction times of three people driving under different conditions.

<table>
<thead>
<tr>
<th>Car driver</th>
<th>Condition</th>
<th>Reaction time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Wide awake with no distractions</td>
<td>0.7</td>
</tr>
<tr>
<td>B</td>
<td>Using a hands-free mobile</td>
<td>0.9</td>
</tr>
</tbody>
</table>
The graph lines show how the thinking distance for the three drivers, A, B and C, depends on how fast they are driving the car.

(i) Match each graph line to the correct driver by writing A, B or C in the box next to the correct line.

(ii) The information in the table cannot be used to tell if driver C's reaction time is increased by being tired or by listening to music.

Explain why.

___________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________

(Total 9 marks)

Q14.

The diagram shows the forces on a small, radio-controlled, flying toy.
(a)  
(i) The mass of the toy is 0.06 kg.
Gravitational field strength = 10 N/kg

Calculate the weight of the toy.

Show clearly how you work out your answer and give the unit.

________________________________________________________________________

________________________________________________________________________

Weight = _________________________

(3)

(ii) Complete the following sentence by drawing a ring around the correct line in the box.

When the toy is hovering stationary in mid-air, the lift force is

bigger than
the same as
smaller than

the weight of the toy.

(1)

(b) When the motor inside the toy is switched off, the toy starts to accelerate downwards.

(i) What does the word accelerate mean?

________________________________________________________________________

(1)

(ii) What is the direction of the resultant force on the falling toy?

________________________________________________________________________

(1)

(Total 6 marks)

---

Q15.

(a) A car driver takes a short time to react to an emergency before applying the brakes. The distance the car will travel during this time is called the ‘thinking distance’.
The graph shows how the thinking distance of a driver depends on the speed of the car.

(i) What is the connection between thinking distance and speed?

___________________________________________________________________________

(1)

(ii) Many people drive while they are tired.

Draw a new line on the graph to show how thinking distance changes with speed for a tired driver.

(1)

(iii) The graph was drawn using data given in the Highway Code.

Do you think that the data given in the Highway Code is likely to be reliable?

Draw a ring around your answer.

Yes  No  Maybe

Give a reason for your answer.

___________________________________________________________________________

___________________________________________________________________________

(1)

(b) The distance a car travels once the brakes are applied is called the 'braking distance'.

(i) What is the relationship between thinking distance, braking distance and stopping distance?

___________________________________________________________________________

(1)

(ii) State two factors that could increase the braking distance of a car at a speed of 15 m/s.

1. __________________________________________________________

2. __________________________________________________________

(2)

(Total 6 marks)
Q16.
A car is driven along a straight road. The graph shows how the velocity of the car changes during part of the journey.

(a) Use the graph to calculate the deceleration of the car between 6 and 9 seconds. Show clearly how you work out your answer and give the unit.

\[
\text{Deceleration} = \frac{\text{change in velocity}}{\text{time}} = \frac{-15 \text{ m/s} - 15 \text{ m/s}}{9 \text{ s} - 6 \text{ s}} = \frac{-30 \text{ m/s}^2}{3 \text{ s}} = -10 \text{ m/s}^2
\]

(b) At what time did the car change direction?

\[\text{At } 6 \text{ seconds}\]

(Total 4 marks)

Q17.
(a) The diagram shows a lampshade hanging from the ceiling. Draw an X on the diagram so that the centre of the X marks the centre of the mass of the lampshade.

(b) Complete the sentence using the correct word or phrase from the box.
A suspended object will come to rest with its centre of mass directly __________________________ the point of suspension.

(1)

(c) The diagrams show equipment that a student uses to find the centre of mass of a thin sheet of card.

Arrange these sentences in the correct order to describe how the student can find the centre of mass of the card.

The sequence starts with sentence D and finishes with sentence E.

A A line is drawn on the card marking the position of the string.
B The pin is put through one of the holes in the card and held in the boss.
C This is repeated using the other hole.
D Two holes are made in the card with each hole near to the edge of the card.
E The centre of mass is where the lines cross on the card.
F The weight is tied to the string and then the string is hung from the pin.

D __________________________ E

(3)

(Total 5 marks)
A car and a bicycle are travelling along a straight road. They have stopped at road works.

The graph shows how the velocity of the car changes after the sign is changed to GO.

(a) Between which two points on the graph is the car moving at constant velocity?

___________________________________________________________________

(1)

(b) Between which two points on the graph is the car accelerating?

___________________________________________________________________

(1)

(c) Between the sign changing to GO and the car starting to move, there is a time delay. This is called the reaction time.

(i) What is the reaction time of the car driver?

Reaction time = _________________ seconds

(1)

(ii) Which one of the following could increase the reaction time of a car driver? Tick the box next to your choice.

Drinking alcohol

Wet roads
Q19.
The diagram shows a sky-diver in free fall. Two forces, X and Y, act on the sky-diver.

(a) Complete these sentences by crossing out the two lines in each box that are wrong.

(i) Force X is caused by 

   - friction
   - gravity
   - weight

(ii) Force Y is caused by

   - air resistance
   - friction
   - gravity

(b) The size of force X changes as the sky-diver falls. Describe the motion of the sky-diver when:

(i) force X is smaller than force Y,

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

   (2)

(ii) force X is equal to force Y.
Q20.

A car travelling along a straight road has to stop and wait at red traffic lights. The graph shows how the velocity of the car changes after the traffic lights turn green.

(a) Between the traffic lights changing to green and the car starting to move there is a time delay. This is called the reaction time. Write down one factor that could affect the driver’s reaction time.

(b) Calculate the distance the car travels while accelerating. Show clearly how you work out your answer.

\[
\text{Distance} = \text{metres}
\]

(c) Calculate the acceleration of the car. Show clearly how you work out your final answer and give the units.

\[
\text{Acceleration} = \text{m/s}^2
\]

(d) The mass of the car is 900 kg.
(i) Write down the equation that links acceleration, force and mass.

(ii) Calculate the force used to accelerate the car. Show clearly how you work out your final answer.

Force = ___________________________ newtons

Q21.
The Boat is a theme park ride. The Boat swings backwards and forwards. The diagrams show the Boat at the top and bottom of its swing.

(a) As the Boat swings from its position in A to its position in B, a child on the ride gains 5070 joules of kinetic energy. The child has a mass of 60 kg and is sitting at the centre.

(i) Write down the equation which links kinetic energy, mass and speed.

(ii) Calculate the speed of the child as the Boat passes through B. Show clearly how you work out your final answer.

Speed = ___________________________ m/s

(b) Sketch a graph to show how the gravitational potential energy of the child changes as the Boat swings from A to B to C. The axes have been drawn for you.
Q22.

The roads were very icy. An accident was recorded by a security camera.

Car A was waiting at a road junction. Car B, travelling at 10 m/s, went into the back of car A. This reduced car B’s speed to 4 m/s and caused car A to move forward.

The total mass of car A was 1200 kg and the total mass of car B was 1500 kg.

(i) Write down the equation, in words, which you need to use to calculate momentum.

(ii) Calculate the change in momentum of car B in this accident.

Show clearly how you work out your final answer and give the unit.

(iii) Use your knowledge of the conservation of momentum to calculate the speed, in
m/s, of car A when it was moved forward in this accident.

Show clearly how you work out your final answer.

___________________________________________________________________

___________________________________________________________________

Speed = ______________________________ m/s

(Total 7 marks)

Q23.

A horse and rider take part in a long distance race. The graph shows how far the horse and rider travel during the race.

(a) What was the distance of the race?

distance = _________________________________ km

(b) How long did it take the horse and rider to complete the race?

___________________________________________________________________

(c) What distance did the horse and rider travel in the first 2 hours of the race?

distance = _________________________________ km

(d) How long did the horse and rider stop and rest during the race?

___________________________________________________________________

(e) Not counting the time it was resting, between which two points was the horse moving the slowest?
Q24.
(a) The arrows in the diagram represent the size and direction of the forces on a space shuttle, fuel tank and booster rockets one second after launch. The longer the arrow the bigger the force.

Thrust force

Weight of shuttle, fuel tanks and booster rockets plus air resistance

(i) Describe the upward motion of the space shuttle one second after launch.

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

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

(ii) By the time it moves out of the Earth’s atmosphere, the total weight of the space shuttle, fuel tank and booster rockets has decreased and so has the air resistance.

How does this change the motion of the space shuttle? (Assume the thrust force does not change).

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

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

(b) The space shuttle takes 9 minutes to reach its orbital velocity of 8100 m/s.

(i) Write down the equation that links acceleration, change in velocity and time taken.

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

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

(ii) Calculate, in m/s², the average acceleration of the space shuttle during the first 9 minutes of its flight. Show clearly how you work out your answer.
average acceleration = _______________________ m/s²

(iii) How is the velocity of an object different from the speed of an object?

Q25.
(a) A chair lift carries two skiers, Greg and Jill, to the top of a ski slope. Greg weighs 700 N and Jill weighs 500 N.

(i) Write down the equation that links distance moved, force applied and work done.

(ii) Calculate the work done to lift Greg and Jill through a vertical height of 200 m. Show clearly how you work out your answer and give the unit.

(b) The chair takes 5 minutes to move from the bottom to the top of the ski slope.

Calculate the power required to lift Greg and Jill to the top of the ski slope. Show clearly how you work out your answer.
power = ___________________________ watts

(c) The chair lift is driven by an electric motor.

(i) Why would the power output of the electric motor need to be larger than your answer to part (b)?

(ii) Complete the following sentence.

When the ski lift is working _________________ energy supplied to the motor is usefully transferred as gravitational _________________ energy.

(Total 8 marks)

Q26.

The distance-time graph represents the motion of a car during a race.

(a) Describe the motion of the car between point A and point D. You should not carry out any calculations.
To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

(b) Calculate the gradient of the graph between point B and point C. Show clearly how you get your answer.

gradient = ________________________________

(Total 6 marks)

Q27.

(a) The diagram shows the horizontal forces that act on a moving motorbike.

(i) Describe the movement of the motorbike when force A equals force B.

(ii) What happens to the speed of the motorbike if force B becomes smaller than force A?

(b) The graph shows how the velocity of a motorbike changes when it is travelling along a straight road.
(i) What was the change in velocity of the motorbike in the first 5 seconds?

(ii) Write down the equation which links acceleration, change in velocity and time taken.

(iii) Calculate the acceleration of the motorbike during the first 5 seconds. Show clearly how you work out your answer and give the unit.

(c) A car is travelling on an icy road.

Describe and explain what might happen to the car when the brakes are applied.
(d) Name three factors, other than weather conditions, which would increase the overall stopping distance of a vehicle.

1. ______________________________________________________________________

2. ______________________________________________________________________

3. ______________________________________________________________________

(Total 13 marks)

Q28.

A machine is used to lift materials on a building site.

(a) (i) Write down the equation that links change in gravitational potential energy, change in vertical height and weight.

______________________________

(1)

(ii) A 25 kg bag of cement is lifted from the ground to the top of the building. Calculate the gain in the gravitational potential energy of the bag of cement.

(On Earth a 1 kg mass has a weight of 10 N.)

______________________________

______________________________

Change in gravitational potential energy = ___________________ joules

(2)

(b) The conveyor belt delivers six bags of cement each minute to the top of the building.

(i) Calculate the useful energy transferred by the machine each second.

Useful energy transfer each second = ______________________ J

(ii) The machine is 40% efficient. Use the following equation to calculate the total energy supplied to the machine each second. Show how you work out your answer.

\[
\text{Efficiency} = \frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}
\]

Total energy supplied each second = ______________________ J

(Total 6 marks)

Q29. (a) When two objects collide, and no other forces act, then conservation of momentum applies.

(i) What does the term conservation of momentum mean?

(ii) Apart from collisions and similar events, give another type of event in which conservation of momentum applies.

(iii) Write, in words, the equation which you need to use to calculate momentum.

(iv) The diagram shows a straight and horizontal runway and two trolleys, X and Y, which can move on the runway.
X has a mass of 0.2 kg and its velocity is 1.2 m/s to the right. Y has a mass of 0.1 kg and is stationary. When X collides with Y they stick together.

Calculate the velocity of the trolleys after the collision.

Show clearly how you work out your answer and give the unit and direction.

Velocity of the trolleys = ____________________________

(v) What assumption did you make in order to calculate your answer to part (a)(iv)?

______________

(b) Just before it hits a target, a bullet has a momentum of 5 kg m/s. It takes 0.00125 s for the target to stop the bullet.

Calculate the force, in newtons, needed to do this.

Write, in words, the equation that you will need to use and show clearly how you work out your answer.

Force = ____________________________ newtons

(3)

(Total 13 marks)

Q30.

The molten rock flowing from an erupting volcano can reach a speed of 8 m/s.

(i) Write down the equation that links kinetic energy, mass and speed.

______________________________

(1)

(ii) Calculate the kinetic energy of 1 tonne of molten rock flowing at 8 m/s.

(1 tonne = 1000 kg)
Q31.

(a) Two skydivers jump from a plane. Each holds a different position in the air.

Complete the following sentence.

Skydiver ____________ will fall faster because_____________________________

___________________________________________________________________
__________________________________________________________

(2)

(b) In the following sentences, cross out in each box the two lines that are wrong.

(i) Force X is caused by

   air resistance
   friction
   gravity

(Total 2 marks)
Q32.

The diagram shows an orbiter, the reusable part of a space shuttle. The data refers to a typical flight.

<table>
<thead>
<tr>
<th>Orbiter data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>78 000 kg</td>
</tr>
<tr>
<td>Orbital speed</td>
<td>7.5 km/s</td>
</tr>
<tr>
<td>Orbital altitude</td>
<td>200 km</td>
</tr>
<tr>
<td>Landing speed</td>
<td>100 m/s</td>
</tr>
<tr>
<td>Flight time</td>
<td>7 days</td>
</tr>
</tbody>
</table>

(a)  
(i) What name is given to the force which keeps the orbiter in orbit around the Earth?

(ii) Use the following equation to calculate the kinetic energy, in joules, of the orbiter while it is in orbit.

\[ \text{kinetic energy} = \frac{1}{2} mv^2 \]
Kinetic energy = _______________ joules

(iii) What happens to most of this kinetic energy as the orbiter re-enters the Earth’s atmosphere?

________________________________________________________________________

________________________________________________________________________

(1)

(b) After touchdown the orbiter decelerates uniformly coming to a halt in 50 s.

(i) Give the equation that links acceleration, time and velocity.

________________________________________________________________________

(1)

(ii) Calculate the deceleration of the orbiter. Show clearly how you work out your answer and give the unit.

________________________________________________________________________

________________________________________________________________________

Deceleration = ________________

(2)

(c) (i) Give the equation that links acceleration, force and mass.

________________________________________________________________________

(1)

(ii) Calculate, in newtons, the force needed to bring the orbiter to a halt. Show clearly how you work out your answer.

________________________________________________________________________

________________________________________________________________________

Force = ________________ newtons

(1)

(Total 9 marks)

Q33.

(a) What is the principle of conservation of momentum?

________________________________________________________________________

________________________________________________________________________

(2)

(b) The diagram shows a simplified aircraft jet engine.
(i) What is the function of the turbine?

________________________________________________________________________

________________________________________________________________________

(1)

(ii) Explain how the engine produces a forward thrust.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(4)

(c) During flight, air enters the engine at 175 m/s and leaves at 475 m/s. A forward thrust of 105 kN is produced.

Use the following equation to calculate the mass of air passing through the engine every second. (Ignore the mass of the burned fuel.)

\[
\text{force} = \frac{\text{change in momentum}}{\text{time}}
\]

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Mass of air = ________________________ kg

(2)

(Total 9 marks)
Q34. 
(a) The weightlifter in the picture has lifted a weight of 2250 newtons above his head. The weight is held still.

(i) In the box are the names of three forms of energy.

gravitational potential  kinetic  sound

Which **one** of these forms of energy does the weight have?

______________________________________________________________

(1)

(ii) What force is used by the weightlifter to hold the weight still?

Size of force = __________________________ N

Give a reason for your answer _____________________________________

______________________________________________________________

______________________________________________________________

(2)

(b) To lift the weight, the weightlifter does 4500 joules of work in 3.0 seconds.

Calculate the power developed by the weightlifter. Show clearly how you work out your answer.

__________________________________________________________

__________________________________________________________

Power = _________________________ watts

(2)

(Total 5 marks)

Q35. 
The picture shows luggage which has been loaded onto a conveyor belt.
Each piece of luggage has a different mass.

Mass of $A = 22$ kg, mass of $B = 12$ kg, mass of $C = 15$ kg

(a) (i) What is the momentum of the luggage before the conveyor belt starts to move?

Give a reason for your answer.

(ii) When the conveyor belt is switched on the luggage moves with a constant speed. Which piece of luggage $A$, $B$ or $C$ has the most momentum?

Give a reason for your answer.

(iii) At one point the conveyor belt turns left. The luggage on the belt continues to move at a constant speed.

Does the momentum of the luggage change as it turns left with the conveyor belt?

Give a reason for your answer.

(b) Draw a circle around the unit which can be used to measure momentum.

$J/s$, $kg \, m/s$, $Nm$
Mark schemes

Q1.
(a) (i) 10800
   *allow 1 mark for correct substitution i.e. 900 × 12*

(ii) arrow pointing towards the left
   *allow anywhere on the diagram or at bottom of the page*

(b) zero
   *accept 0 / none / nothing*
   *velocity is zero*
   *accept speed for velocity*
   *accept stopped / not moving*
   *accept a calculation i.e. 900 × 0 = 0*

Q2.
(a) correct box ticked

(b) each passenger has a different mass
   *accept weight for mass*
   *ignore other irrelevant factors about the person e.g. mass and height*
   *do not accept a list with incorrect factors e.g. mass and position*
   *accept passengers started with different (gravitational) potential energy*

(c) (i) 29.4
   *ignore added units*

(ii) 2400
   *accept their (c)(i) × 80 correctly calculated for both marks*
allow 1 mark for correct substitution of their (c)(i) and 80
an answer of 800 gains 1 mark only if answer to (c)(i) is not 10

2 [5]

Q3.

(a) (i) 4.5
allow 1 mark for correct substitution i.e. 9 ÷ 2

(ii) m/s²
accept answer given in (a)(i) if not contradicted here

(iii) speed

(iv) straight line from the origin passing through (2s, 9m/s)
allow 1 mark for straight line from the origin passing through
to t = 2 seconds
allow 1 mark for an attempt to draw a straight line from the
origin passing through (2,9)
allow 1 mark for a minimum of 3 points plotted with no line
provided if joined up would give correct answer. Points must
include(0,0) and (2,9)

2

(b) (i) B
if A or C given scores 0 marks in total

smallest (impact) force

on all/ every/ any surfaces
these marks are awarded for comparative answers

1

(ii) (conditions) can be repeated

or
difficult to measure forces with human athletes
accept answers in terms of variations in human athletes e.g.
athletes may have different weights area / size of feet may
be different difficult to measure forces athletes run at
different speeds
accept any answer that states or implies that with humans
the conditions needed to repeat tests may not be constant
e.g.
athletes unable to maintain constant speed during tests (or
during repeat tests)
do not accept the robots are more accurate
removes human error is insufficient
fair test is insufficient

1
Q4.
(a) shallowest slope/gradient
   accept smallest distance in biggest time
   accept longest time to travel the same distance
   accept the line is not as steep
   accept it is a less steep line
   *do not* accept the line is not steep
   1

(b) A – B
   *If 2 or 3 boxes are ticked no mark*
   1

(c) (i) 200 m
   1

   (ii) 20 s
       *allow 1 mark for correctly identifying 60 s or 40 s from the graph*
   2

(d) (i) straight line starting at origin
    *accept within one small square of the origin*
    passing through \( t = 200 \) and \( d = 500 \)
    1

   (ii) 166
    *accept any value between 162 and 168*
    *accept where their line intersects given graph line correctly read ± 3 s*
    1

Q5.
(a) (i) 50 (N)
    *ignore any units*
    1

   (ii) resultant force
    1

   (iii) 4000
    *accept their (a)(i) \( \times 80 \) correctly calculated for 2 marks*
    *allow 1 mark for correct substitution i.e. \( 50 \times 80 \) or their (a)(i) \( \times 80 \)*
    *ignore any units*
    2

(b) (i) joule
    1

   (ii) heat
    1
Q6.
(a) gravity
accept weight
*do not* accept mass
accept gravitational pull

(b) (i) Initially force L greater than force M
accept there is a resultant force downwards
(as speed increases) force M increases
accept the resultant force decreases
when M = L, (speed is constant)
accept resultant force is 0
accept gravity/weighty for L
accept drag/ upthrust/resistance/friction for M
*do not* accept air resistance for M but penalise only once

(ii) terminal velocity

(iii) 0.15
accept an answer between 0.14 – 0.16
an answer of 0.1 gains no credit
allow 1 mark for showing correct use of the graph

Q7.
(a) 47250
answers of 1350/ 33750/ 48600 gain 1 mark
allow 1 mark for correct substitution using both 18 and 3

(b) (i) 47250 or their (a)
accept statement ‘same as the KE (lost)’
ignore any units

(ii) transformed into heat/ thermal energy
sound on its own is insufficient
accept transferred/ lost/ for transformed
*do not* accept any other form of energy included as a list

Q8.
(a) (i) centre of X directly below P and between the model aeroplanes
as judged by eye but between centre of propeller of top aeroplane and canopy of bottom aeroplane
(ii) the centre of mass is (vertically) below the point of suspension / P

the centre of mass is in the middle of the aeroplanes
accept the centre of mass is level with the aeroplanes

(b) centre of mass of the worker and the ladder (and device)

line of action of the weight is inside the base
accept the centre of mass is above / within / inside the base
(of the ladder and device)

so there will not be a (resultant) moment
accept so he / it / the ladder will not topple even if he leans over

or it will (only) topple over if the line of action of the weight / the centre of mass is outside the base
accept each point, either on the diagram or in the written explanation, but do not accept the point if there is any contradiction between them

Q9.

(a) B or bungee cords

C or springs or playground ride
each additional answer loses 1 mark minimum mark zero

will go back to original shape/size
(b) (i) newton

(ii) 0 – 5 (N) or 5
   accept 1 – 5 (N)
   do not accept 4

(iii) 16 (cm)

(iv) 2.5 (N)
   accept answer between 2.4 and 2.6 inclusive

Q10.
(a) (i) constant

(ii) heat

(b) (i) 3 links correct

[Chart A]

[Chart B]

[Chart C]

allow 1 mark for 1 correct link
if more than one line is drawn from a condition mark all lines from that condition incorrect

(ii) increased

Q11.
(a) (i) a single force that has the same effect as all the forces combined
   accept all the forces added / the sum of the forces / overall force

(ii) constant speed (in a straight line)
   do not accept stationary
   or constant velocity

(b) 3
   allow 1 mark for correct substitution into transformed equation
accept answer 0.003 gains 1 mark
answer = 0.75 gains 1 mark

m/s^2

(c) as speed increases air resistance increases
   accept drag / friction for air resistance
   reducing the resultant force

Q12.
(a) centre of X at the point where the axes cross
to within 1 mm in any direction

(b) (i) (at / in the) centre (of the tyre)
or unambiguously shown on the diagram

(ii) (this is) where axes of symmetry (of the tyre) cross / intersect / meet
or point at which the mass of the tyre seems to be
(concentrated)

Q13.
(a) 53 (m)

(b) (i) Similar shape curve drawn above existing line going through (0, 0)
allow 1 mark for any upward smooth curve or straight
upward line above existing line going through (0, 0)

(ii) rain on road
car brakes in bad condition

(c) (i) all three lines correctly labelled
allow 1 mark for one correctly labelled
top line – C
accept 1.2
middle line – B
accept 0.9
bottom line – A
accept 0.7
(ii) any two from:

- (table has) both variables are together
  
  accept tired and music as named variables

- both (variables) could/ would affect the reaction time

- cannot tell original contribution
  
  accept cannot tell which variable is affecting the drive (the most)

- need to measure one (variable) on its own
  
  accept need to test each separately

- need to control one of the variables


Q14.

(a) (i) 0.6

allow 1 mark for correct substitution

newtons

accept N

do not accept n

accept Newtons

(ii) the same as

(b) (i) changed velocity

accept increased/ decreased for change

accept speed for velocity

accept change direction

accept getting faster/ slower

accept start/ stop moving

accept correct equation in terms of change in speed or change in velocity

(ii) down(wards)

accept towards the ground

accept ↓

do not accept south

Q15.

(a) (i) as one goes up so does the other

or (directly) proportional

accept change by the same ratio
(ii) steeper straight line through the origin
judge by eye

(iii) Yes with reason
   eg data would have been checked / repeated
   accept produced by a reliable/ official/ government source
do not accept it needs to be reliable
   or No with reason
   eg does not apply to all conditions / cars / drivers
   or are only average values
   or Maybe with a suitable reason
   eg cannot tell due to insufficient information

(b) (i) stopping distance = thinking distance + braking distance

(ii) any two from:
   factors must be to do with increasing braking distance
   • smooth road / loose surface
   • rain / snow / ice
   accept wet road/ petrol spills
do not accept condition of road unless suitably qualified
   • badly maintained brakes
   accept worn brakes
   accept bad/ worn/ rusty brakes
do not accept old brakes
   • worn tyres
   accept bald tyres
   accept lack of grip on tyres
do not accept old tyres
   • downhill slope/gradient
   • heavily loaded car

Q16.
(a) 4
allow 1 mark for extracting correct information 12

m/s²
ignore negative sign
Q17.
(a) centre of X should appear to be on the continued line of the flex and in the body of the lamp as judged by eye

```
example
```

(b) below

(c) (D)→B→F→A→C→(E)
   all four correct for 3 marks
   or any two correct for 2 marks
   or just one correct for 1 mark

Q18.
(a) MN
   accept 5.8, 8 seconds must include unit

(b) LM
   accept 0.8, 5.8 seconds must include unit

(c) (i) 0.8

   (ii) drinking alcohol

(d) straight (by eye) line starting at 0.8 seconds
   line drawn steeper than LM starting before L
   ignore lines going beyond 2 seconds but line must exceed 2.5 metres per second before terminating

Q19.
(a) (i) friction
   accept any way of indicating the correct answer
(ii) gravity
accept any way of indicating the correct answer 1

(b) (i) accelerates or speed / velocity increases
accept faster and faster (1 mark)
do not accept faster pace / falls faster
or suggestions of a greater but constant speed 1
downwards / falls
accept towards the Earth / ground
this may score in part (b)(ii) if it does not score here and
there is no contradiction between the two parts 1

(ii) constant speed / velocity or terminal velocity / speed or zero acceleration
stays in the same place negates credit 1

Q20.

(a) concentration / tiredness / drugs / alcohol
accept any reasonable factor that could affect a driver’s reactions
do not accept speed or any physical condition unrelated to the driver 1

(b) 31.25
credit for 1 mark correct attempt to calculate the area under the slope or for using the equation
distance = average velocity (speed) × time
credit for 1 mark use of correct velocity change (12.5) and correct time (5) or answer of 62.5 3

(c) 2.5
credit for 1 mark triangle drawn on slope or correct equation or two correct pairs of coordinates
credit for 1 mark use of correct velocity change (12.5) and correct time (5)
accept time = between 4.8 and 5.2 if used in (b)
do not accept an attempt using one pair of coordinates taken from the slope

metres / second / second or metres / second / squared or m/s² or ms⁻² 1

(d) (i) force = mass × acceleration
accept correct transformation
accept $F = m \times a$

accept $\Delta$ provided subsequent use of $\Delta$ is correct
do not accept an equation in units

(ii) 2250
credit their (c) × 900 for 2 marks
credit 1 mark for correct substitution

Q21.

(a) (i) kinetic energy = \( \frac{1}{2} \times \text{mass} \times \text{speed}^2 \)
accept \( \frac{1}{2} \text{mv}^2 \)
do not accept \( \frac{1}{2} \text{ms}^2 \)

(ii) 13
allow 1 mark for correct substitution or transformation

(b) if B is at the top of the curve - no marks
PE at A maximum
PE at B minimum
PE at C just less than or = to A
do not accept wavy lines or very non-symmetrical
accept straight lines or curves
difference between A and B is 5000 to 5200

Q22.

(i) momentum (change in) = mass × velocity (change in)
accept ... speed

(ii) 9000
1500 × 6 for 1 mark but not from incorrect equation
kilogram metre(s) per second or kg m/s

(iii) either 7.5 (m/s)
or change in momentum of car B change in momentum of car A (1)
9000 = 1200 × v (1)
or \( v = 9000 \div 1200 \) (1)

or error carried forward from part (ii)

**Examples**

5 (m/s) if 6000 offered in (ii) (3)

12.5(m/s) if 15000 offered in (ii) (3)

---

Q23.

(a) 60

(b) 5 \( \frac{1}{2} \) hours

\[ \text{must include unit} \]

(c) 30

(d) 30 minutes or

\( \frac{1}{2} \) hour

\[ \text{must include unit} \]

(e) D and E

\[ \text{accept finish for E} \]

\[ \text{accept correct numbers from axes with units} \]

least steep part of the graph

\[ \text{accept covers smallest distance in a set time} \]

\[ \text{accept only moves 5 km in 1 \( \frac{1}{2} \) hours (accept anything between 5 and 6)} \]

\[ \text{ignore horse is tired} \]

---

Q24.

(a) (i) accelerating

\[ \text{accept getting faster} \]

\[ \text{accept speed / velocity increasing} \]

(ii) acceleration increases

\[ \text{accept velocity / speed increases more rapidly} \]

\[ \text{do not accept velocity / speed increases} \]

(b) (i) acceleration = \[
\frac{\text{change in velocity}}{\text{time (taken)}}
\]
\[
\frac{v - u}{t} \quad \text{or} \quad \frac{v_1 - v_2}{t}
\]

*do not* accept velocity for change in velocity
*do not* accept change in speed

*do not* accept \( a = \frac{v}{t} \)

(ii) 15

*allow 1 mark for an answer of 900 or correct use of 540 seconds*

(iii) velocity includes direction

*accept velocity is a vector (quantity)*

*accept converse answer*

Q25.

(a) (i) work (done) = force (applied) \times distance (moved)

*accept \( W = F \times s \) or \( W = F \times d \)

*accept \( \frac{W}{F} \) provided subsequent method is correct*

(ii) 240 000

*allow 1 mark for correct substitution or correct use of 1200 (N)*

jojules

*accept J*

*do not accept \( j / Nm \)*

(b) 800 (watts)

*accept 0.8 kW*

*accept their (a)(ii) \( \div 300 \) correctly evaluated for 2 marks*

*allow 1 mark for correct substitution*

*(a)(ii) \( \div 5 \) correctly evaluated for 1 mark*

(c) (i) any one from:

*needs to raise the chair / lift*

*lifting more than one chair*

*allow lifting more than 2 people*

*implication of a heavier weight*
• energy transfer to the surroundings correctly qualified
  accept loss for transfer
do not accept motor inefficient
do not accept motor gets hot
do not accept friction unless the location is specified as external to the motor

(ii) electrical
  accept electric potential
  both answers required for the mark

Q26.
(a) Quality of written communication
  for correct use of term speed in all correct examples
  Q ✓ Q ✗

  describes all 3 sections correctly for 2 marks
  describes 2 or 1 section correctly for 1 mark
  max 2

  A – B constant speed
    do not accept pace for speed

  B – C (has accelerated) to a higher (constant) speed

  C – D goes back to original / lower (constant) speed
    allow for 1 mark, initial and final (constant) speeds are the same accept velocity for speed
    ignore reference to direction

(b) 62.5

  allow answer to 2 s.f.
  allow 1 mark for drawing a correct triangle or for using two correct pairs of coordinates
  allow 1 mark for correct use of y/x
  ignore units

Q27.
(a) (i) constant speed
    do not accept normal speed
    do not accept it is stopped / stationary

  in a straight line
    accept any appropriate reference to a direction
    constant velocity gains 2 marks
'not accelerating' gains 2 marks
terminal velocity alone gets 1 mark

(ii) goes down owtte
accept motorbike (it) slows down

(b) (i) 20 (m/s)
ignore incorrect units

change in velocity
\[
\text{acceleration } = \frac{\Delta v}{\text{time (taken)}}
\]

\[
do\ not\ accept\ velocity\ for\ change\ in\ velocity\ 
accept\ change\ in\ speed\ 
\]

\[
\begin{align*}
\text{acceleration } &= \frac{v - u}{t} \\
\text{or } a &= \frac{v - v_i}{t}
\end{align*}
\]

\[
\text{or } a = \frac{\Delta v}{t}
\]

do not accept \( \frac{v}{t} \)

(ii) acceleration = \( \frac{v}{t} \)

(iii) 4

or their (b)(i) \( \div 5 \)

allow 1 mark for correct substitution

m/s²:
m/s/s or \( \text{ms}^{-2} \) or metres per
second squared or metres per
second per second

(c) vehicle may skid / slide
loss of control / brakes lock / wheels lock
accept greater stopping distance or difficult to stop

due to reduced friction (between tyre(s) and road)
accept due to less grip
do not accept no friction

(d) any three from:
do not accept night time / poor vision

• increased speed
• reduced braking force
• slower (driver) reactions
NB specific answers may each gain credit eg tiredness (1), drinking alcohol (1), using drugs (1), driver distracted (1) etc

- **poor** vehicle maintenance
  - *specific examples may each gain credit eg worn brakes or worn tyres etc*

- **increased** mass / weight of vehicle
  - accept large mass / weight of vehicle

- **poor** road surface

- **more** streamlined
  - *if candidates give three answers that affect stopping distance but not specific to increase award 1 mark only*

Q28.

(a) (i) \( gpe = \text{weight} \times \text{height} \)
  - accept \( Ep = mgh \)
  - accept \( pe = mgh \)

(ii) 1200
  - accept values using 9.8 (1)
  - allow 1 mark for correct substitution

(b) (i) 120
  - their (a)(ii) \( \times 6 \)
  - accept \( \frac{50}{6} \)

(ii) 300
  - allow b(i) \( \div 0.4 \) for both marks
  - allow 1 mark for correct transformation

Q29.

(a) (i) \textit{either}

  - the momentum in a particular direction after (the collision) is the same as the momentum in that direction before (the collision)
  - accept 'momentum before equals momentum after' for 1 mark

  - or \textit{total} momentum after (the collision) equals the \textit{total} momentum before (the collision) (2)
  - accept 'momentum before equals momentum after' for 1 mark

(ii) explosion(s)
  - or (action of a) rocket (motor(s))
  - or (action of a) jet (engine)
or firing a gun
accept any other activity in which things move apart as a result of the release of internal energy eg throwing a ball

(iii) momentum = mass × velocity or any correctly transposed version
accept momentum = mass × speed
accept \( p = mv \)
do not accept momentum = \( ms \)
or \( M = mv \)

(iv) 0.8
if answer 0.8 not given, any two for (1) each:
momentum of \( X \) = 0.2 × 1.2
= momentum of \( X \) and \( Y \) after impact
= 0.3 × \( v \) or \((0.1 + 0.2) \times v\)

m/s

to the right

(v) any one from:
conservation of momentum (applies)
no external forces
do not accept just ‘no (other) forces act’
friction is negligible / insignificant
no friction
no air resistance

(b) force = (change in) momentum ÷ time
or any correctly transposed version

4000 or 4 kilonewtons
dependent on correct or no equation
force = 5 ÷ 0.00125 gains 1 mark

Q30.

(i) kinetic energy = \( \frac{1}{2} \times \text{mass} \times \text{speed}^2 \)

accept velocity for speed
\[ KE = \frac{1}{2} mv^2 \]

(ii) 32 000

accept 32 kJ

Q31.
(a) B

more aerodynamic or most streamlined shape or smaller (surface) area

accept less air/wind resistance or less drag or less friction
clothing traps less air or rolled up into ball or arms, legs drawn in

accept converse

(b) (i) gravity

(ii) air resistance

(iii) go up

(iv) stays the same

(c) bigger the area, the bigger force Y

accept the converse

or bigger the area more drag

accept when the parachute opens then force Y bigger

or bigger the area more air resistance

need the relation of area to force

Q32.
(a) (i) gravity/weight

(ii) 2193750000000 or 2.19 \times 10^{12}

not 2.19^{12}

allow 1 mark for the correct conversion to 7500 (m/s)
allow one mark for answer 2193750(J)

transferred to heat

ignore extras of sound and light

accept changed to heat
accept lost due to friction

\[
\text{acceleration} = \frac{\text{change in velocity}}{\text{time (taken)}}
\]

accept word speed instead of velocity

\[
\frac{v - u}{t}
\]

accept \( a = \)

or correct rearrangement
do not accept

\[\begin{array}{c}
V \\
a \\
t
\end{array}\]
even if subsequent calculation correct

\[\begin{array}{c}
v - u \\
a \\
t
\end{array}\]

can gain credit if subsequent calculation correct

(ii) 2

ignore + or – signs

\[\text{m/s}^2 \quad 1\]

accept \( m/s/s \) or \( ms^2 \)

(c) (i) force = mass \( \times \) acceleration

accept correct rearrangement

accept \( F = m \times a \)
do not accept

\[\begin{array}{c}
f \\
m \\
a
\end{array}\]

unless subsequent calculation correct

(ii) 156 000

accept 78 000 \times \text{their (b)(ii)(only if (b)(i) correct)}

Q33.

(a) Total momentum (of a system of bodies) remains constant
accept momentum before (a collision) = momentum after (a collision)  

Provided no external force acts  

(b) (i) rotate the compressor  

(ii) • fuel is mixed with the air and ignited  
• causing an increase in the pressure or temperature or speed of the gases  
accept air out faster than air in  
accept gases have momentum or  
• force backwards  
• exhaust gases have momentum (backwards) or force (backwards)  
if the answer is in terms of force then this third point must be scored before the fourth can be credited  
• engine or aircraft has (equal) momentum forwards or force forwards  

(c) \( m = 350 \)  
answer 0.35 one mark only  
allow one mark if 105 000 or 475-175 or 300 have been used  

Q34.  

(a) (i) gravitational potential  
accept gravitational  
accept potential  

(ii) 2250 (N)  
forces must be balanced  
or  
forces are equal and opposite  
\( \text{do not accept because it is not moving} \)  
\( \text{do not accept 'equilibrium' by itself} \)  
\( \text{do not accept 'it is not balanced'} \)  
\( \text{do not accept 'forces are equal'} \)  
\( \text{do not accept 'forces are the same'} \)  

(b) 1500  
\( 1 \) mark for correct substitution
Q35.

(a) (i) zero
    accept nothing
    1
    speed is zero
    accept not moving
    1

(ii) A
    largest mass or weight
    accept heaviest luggage
    do not accept largest luggage
    1

(iii) momentum does change
    accept yes
    1
    direction is changing
    accept velocity is changing
    do not accept answers in terms of speed changing
    1

(b) kg m/s
    1