Exampro GCSE Physics

P2 Momentum and Energy Calculations Self Study Higher tier

Name:

Class:

Author:

Date:

Time: 110

Marks: 110

Comments:

Q1. The figure below shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

(a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

....

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....

(3)

(b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m / s.

Use the correct equation from the Physics Equations Sheet.

....

....

....

....

....

....

Velocity of skateboard = ... m / s

(3)
(Total 6 marks)

Q2. (a) In any collision, the total momentum of the colliding objects is usually conserved.

(i) What is meant by the term 'momentum is conserved'?

....

....

(1)

(ii) In a collision, momentum is **not always** conserved.

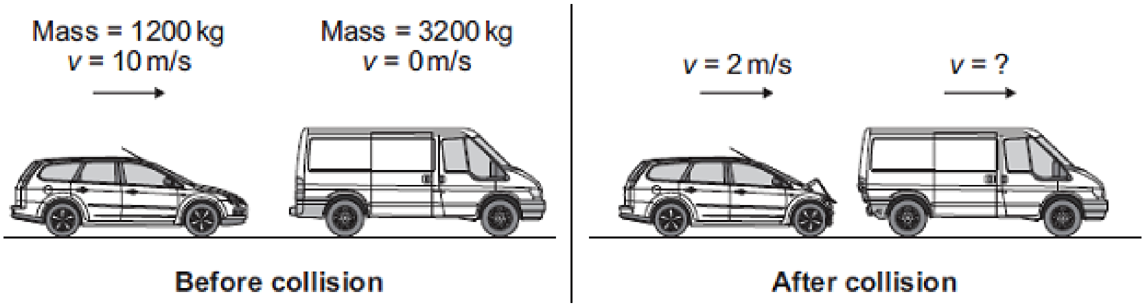
Why?

....

....

(1)

(b) The diagram shows a car and a van, just before and just after the car collided with the van.



(i) Use the information in the diagram and the equation in the box to calculate the **change** in the momentum of the car.

momentum = mass x velocity

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

....

....

....

....

Change in momentum = ...

(3)

(ii) Use the idea of conservation of momentum to calculate the velocity of the van when it is pushed forward by the collision.

Show clearly how you work out your answer.

....

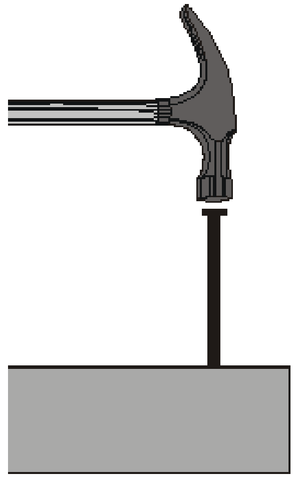
....

....

Velocity = ... m/s forward

(2)
(Total 7 marks)

Q3. (a) The diagram shows a hammer which is just about to drive a nail into a block of wood.



The mass of the hammer is 0.75 kg and its velocity, just before it hits the nail, is 15.0 m/s downward. After hitting the nail, the hammer remains in contact with it for 0.1 s. After this time both the hammer and the nail have stopped moving.

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

....

(1)

(ii) What is the momentum of the hammer just before it hits the nail?

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

....

....

....

Momentum = ...

(3)

(iii) What is the change in momentum of the hammer during the time it is in contact with the nail?

....

(1)

(iv) Write down an equation which connects *change in momentum*, *force* and *time*.

....

(1)

(v) Calculate the force applied by the hammer to the nail.

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

....

....

....

Force = ...

(3)

(b) A magazine article states that:

"Wearing a seat belt can save your life in a car crash."

Use your understanding of momentum to explain how this is correct.

....

....

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....

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....

....

....

(4)
(Total 13 marks)

Q4. (a) In any collision, the total momentum of the colliding objects is usually conserved.

(i) What is meant by the term 'momentum is conserved'?

....

....

(1)

(ii) In a collision, momentum is **not** always conserved.

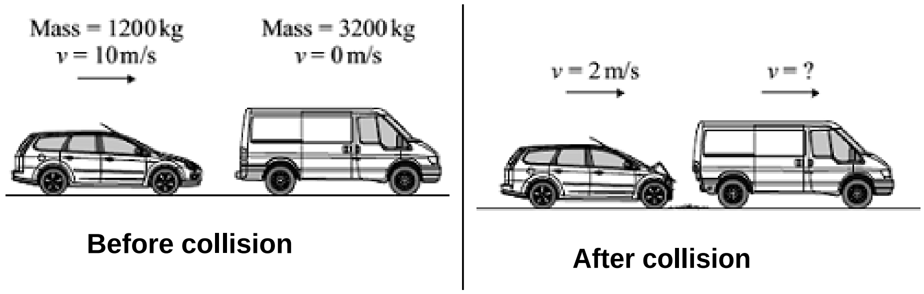
Why?

....

....

(1)

(b) The diagram shows a car and a van, just before and just after the car collided with the van.



(i) Use the information in the diagram and the equation in the box to calculate the **change** in the momentum of the car.

momentum = mass × velocity

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

....

....

....

....

Change in momentum =...

(3)

(ii) Use the idea of conservation of momentum to calculate the velocity of the van when it is pushed forward by the collision.

Show clearly how you work out your answer.

....

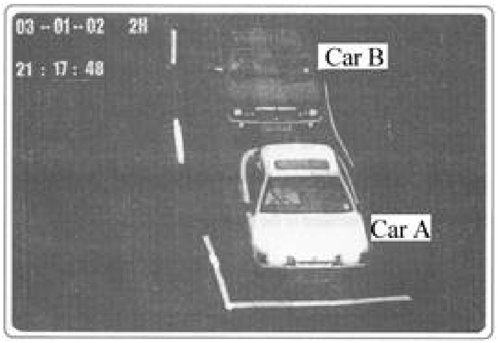
....

....

Velocity =... m/s forward

(2)
(Total 7 marks)

Q5. 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.

....

(1)

(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.

....

....

Change in momentum = ...

(3)

(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.

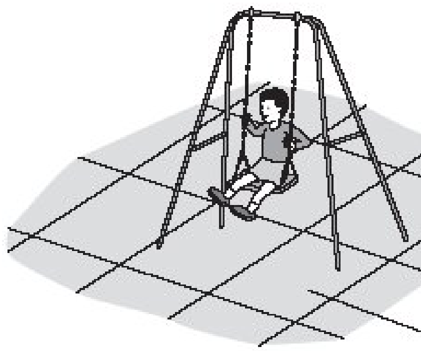
....

....

Speed = ... m/s

(3)
(Total 7 marks)

Q6. The diagram shows a child on a playground swing.
The playground has a rubber safety surface.



(a) The child, with a mass of 35 kg, falls off the swing and hits the ground at a speed of 6 m/s.

(i) Use the equation in the box to calculate the momentum of the child as it hits the ground.

momentum = mass × velocity

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

....

....

....

Momentum = ...

(3)

(ii) After hitting the ground, the child slows down and stops in 0.25 s.
Use the equation in the box to calculate the force exerted by the ground on the child.

$$\text{force} = \frac{\text{change in momentum}}{\text{time taken for the change}}$$

Show clearly how you work out your answer.

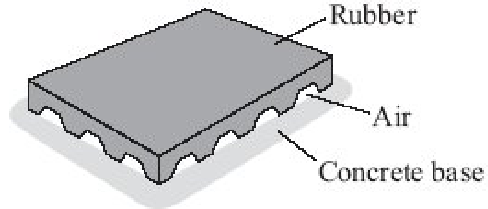
....

....

Force = ... N

(2)

(b) The diagram shows the type of rubber tile used to cover the playground surface.



Explain how the rubber tiles reduce the risk of children being seriously injured when they fall off the playground equipment.

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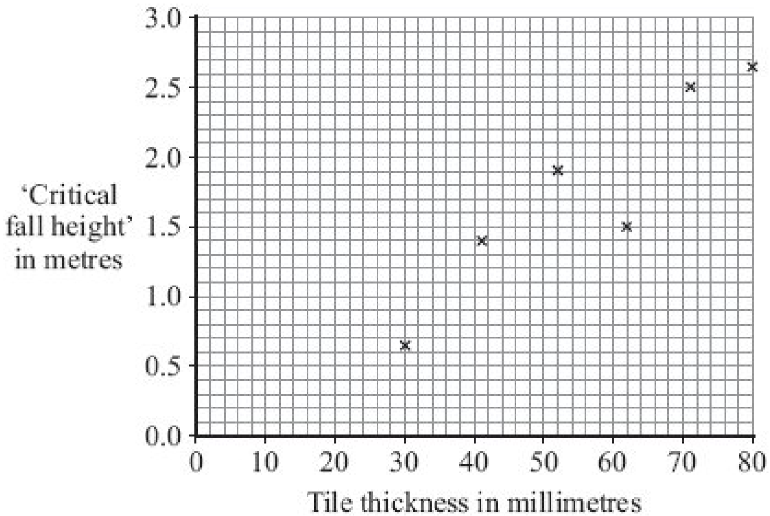
....

....

(3)

(c) The 'critical fall height' is the height that a child can fall and **not** be expected to sustain a life-threatening head injury.
A new type of tile, made in a range of different thicknesses, was tested in a laboratory using test dummies and the 'critical fall height' measured. Only one test was completed on each tile.

The results are shown in the graph.



The 'critical fall height' for playground equipment varies from 0.5 m to 3.0 m.

Suggest **two** reasons why more tests are needed before this new type of tile can be used in a playground.

1 ....

....

2 ....

....

(2)

(d) Developments in technology allow manufacturers to make rubber tiles from scrap car tyres.

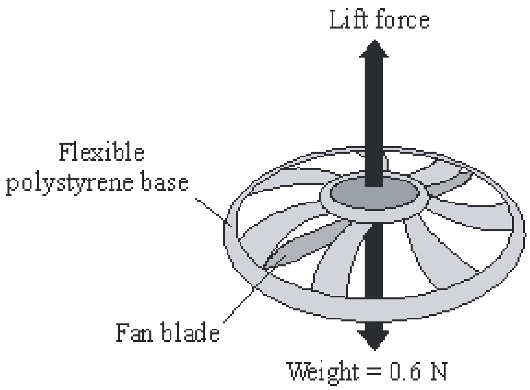
Suggest why this process may benefit the environment.

....

....

(1)
(Total 11 marks)

Q7. The diagram shows a small, radio-controlled, flying toy. A fan inside the toy pushes air downwards creating the lift force on the toy.



When the toy is hovering in mid-air, the fan is pushing 1.5 kg of air downwards every 10 seconds. Before the toy is switched on, the air is stationary.

(a) Use the equations in the box to calculate the velocity of the air when the toy is hovering.

momentum = mass × velocity
force = $\frac{\text{change in momentum}}{\text{time taken for the change}}$

Show clearly how you work out your answer.

....

....

....

Velocity = ... m/s

(3)

(b) Explain why the toy accelerates upwards when the fan rotates faster.

....

....

....

....

(2)

(c) The toy is not easy to control so it often falls to the ground.

Explain how the flexible polystyrene base helps to protect the toy from being damaged when it crashes into the ground.

....

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....

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....

....

(3)
(Total 8 marks)

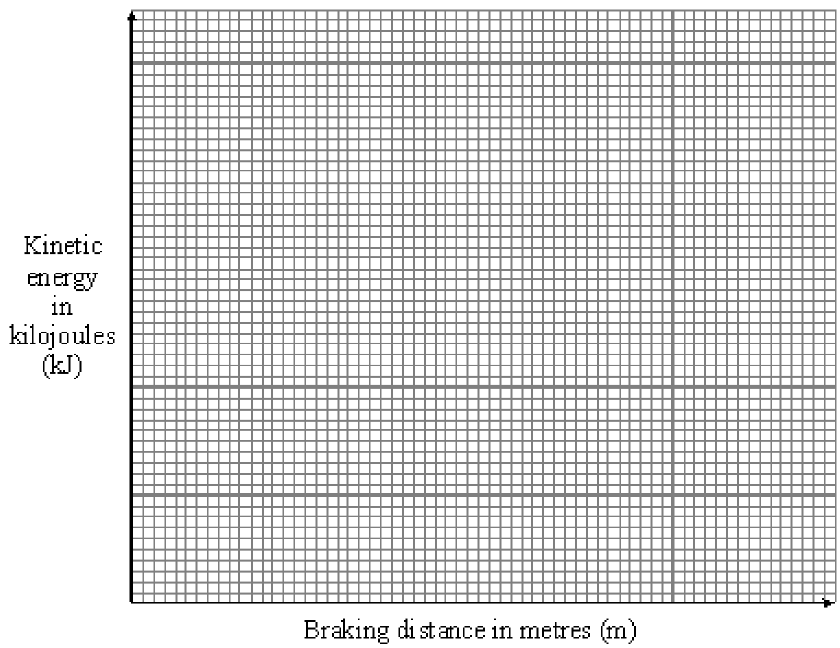
##

The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

Braking distance in m	**Speed of car in m/s**	**Kinetic energy of car in kJ**
5	10	40
12	15	90
20	20	160
33	25	250
45	30	360

(a) A student suggests, "*the braking distance is directly proportional to the kinetic energy*."

(i) Draw a line graph to test this suggestion.



(3)

(ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

....

....

(1)

(iii) Use your graph and the following equation to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

kinetic energy = $\frac{1}{2} mv^2$

....

....

Braking distance = ... m

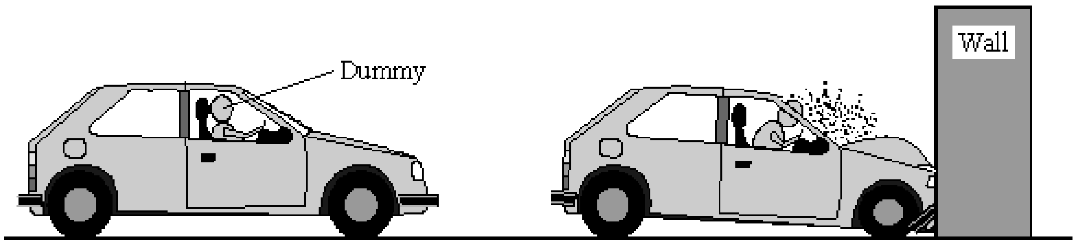
(2)

(iv) State **one** factor, apart from speed, which would increase the car's braking distance.

....

(1)

(b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.



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

....

(1)

(ii) Calculate the deceleration of the car.

....

Deceleration = ... m/s^2

(1)

(iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

By increasing the time it takes for the car to stop, the ....

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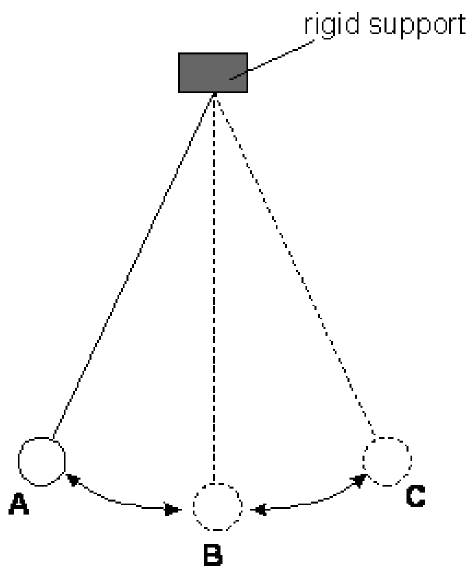
(2)

(Total 11 marks)

Q9. The diagram below shows an experiment where a pendulum swings backwards and forwards.
A pendulum is a small heavy weight suspended by a light string.



(a) (i) In which position, A, B or C, does the pendulum have least potential energy?
Explain your answer.

....

(1)

(ii) In which position, A, B or C, does the pendulum have greatest kinetic energy?

Explain your answer.

....

(1)

(iii) After a few minutes the size of the swings becomes smaller.
Explain why this happens.

....

....

(1)

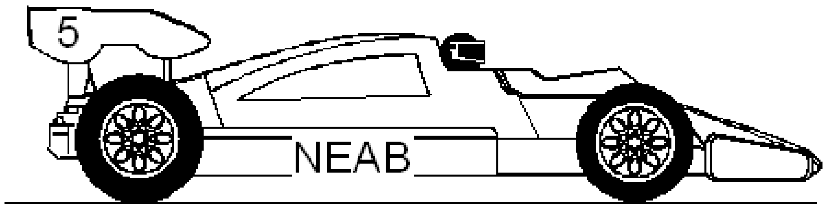
(b) If the experiment were repeated on the Moon the pendulum would swing more slowly.
Suggest a reason for this.

....

....

(2)
(Total 5 marks)

Q10. A racing driver is driving his car along a **straight** and **level** road as shown in the diagram below.



(a) The driver pushes the accelerator pedal as far down as possible. The car does not accelerate above a certain maximum speed. Explain the reasons for this in terms of the forces acting on the car.

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....

(4)

(b) The racing car has a mass of 1250 kg. When the brake pedal is pushed down a constant braking force of 10 000 N is exerted on the car.

(i) Calculate the acceleration of the car.

....

....

....

....

....

(ii) Calculate the kinetic energy of the car when it is travelling at a speed of 48 m/s.

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....

....

(iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

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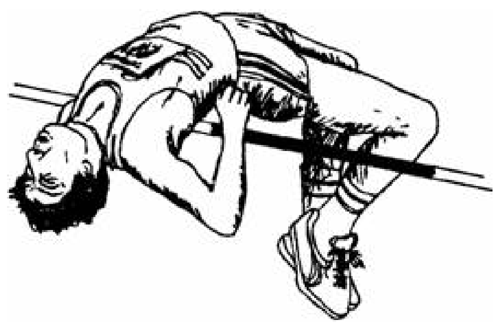
(12)
(Total 16 marks)

Q11. The diagram shows a high jumper.



In order to jump over the bar, the high jumper must raise his mass by 1.25 m.
The high jumper has a mass of 65 kg. The gravitational field strength is 10 N/kg.

(a) The high jumper just clears the bar.

Use the following equations to calculate the gain in his gravitational potential energy.

weight	=	mass	×	gravitational field strength
(newton, N)		(kilogram, kg)		(newton/kilogram, N/kg)

change in gravitational potential energy = weight × change in vertical height

(joule, J) (Newton, N) (metre, m)

....

....

....

....

....

....

Gain in gravitational potential energy .... J

(4

(b) Use the following equation to calculate the minimum speed the high jumper must reach for take-off in order to jump over the bar.

kinetic energy = $\frac{1}{2}$ × mass × [speed]^2

(joule, J) (kilogram, kg) [(metre/second)^2, (m/s)^2

....

....

....

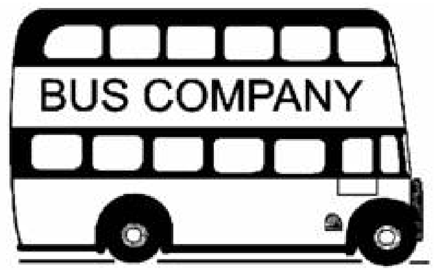
....

....

Speed .... m/s

(3)
(Total 7 marks)

Q12. **'SPEED KILLS' -** was the heading of an advertising campaign. The scientific reason for this is that energy is transferred from the vehicle to the person it knocks down.



(a) The bus and the van are travelling at the same speed. The bus is more likely to cause more harm to a person who is knocked down than the van would. Explain why.

....

....

....

(2)

(b) A car and its passengers have a mass of 1200 kg. It is travelling at 12 m/s.

(i) Calculate the increase in kinetic energy when the car increases its speed to 18 m/s.

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

....

....

....

....

....

....

....

....

Increase in kinetic energy = ...

(5)

(ii) Explain why the increase in kinetic energy is much greater than the increase in speed.

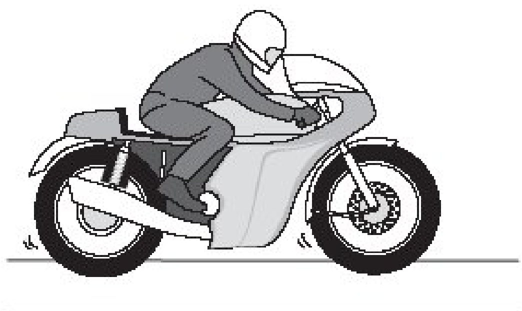
....

....

....

(1)
(Total 8 marks)

Q13. 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) Use the equation in the box to calculate the kinetic energy lost by the motorbike.

kinetic energy = $\frac{1}{2}$ × mass × speed^2

Show clearly how you work out your answer.

....

....

....

....

Kinetic energy lost = ... J

(2)

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

....

(1)

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

....

(1)
(Total 4 marks)

M1. (a) momentum before (jumping) = momentum after (jumping)

accept momentum (of the skateboard and skateboarder) is conserved

1

before (jumping) momentum of skateboard and skateboarder is zero

accept before (jumping) momentum of skateboard is zero

accept before (jumping) total momentum is zero

1

after (jumping) skateboarder has momentum (forwards) so skateboard must have (equal) momentum (backwards)

answers only in terms of equal and opposite forces are insufficient

1

(b) 7

*accept –7 for **3** marks*

*allow **2** marks for momentum of skateboarder equals 12.6*

or

0 = 42 × 0.3 + (1.8 × –v)

or

*allow **1** mark for stating use of conservation of momentum*

3

[6]

M2. (a) (i) momentum before = momentum after

accept no momentum is lost

accept no momentum is gained

or

(total) momentum stays the same

1

(ii) an external force acts (on the colliding objects)

accept colliding objects are not isolated

1

(b) (i) 9600

allow 1 mark for correct calculation of momentum before or after ie 12000 or 2400

or

correct substitution using change in velocity = 8 m/s

ie 1200 × 8

2

kg m/s

or

Ns

this may be given in words rather than symbols

*do **not** accept nS*

1

(ii) 3 or their (b)(i) ÷ 3200 correctly calculated

allow 1 mark for stating momentum before = momentum after

or

clear attempt to use conservation of momentum

2

[7]

M3. (a) (i) momentum = mass × velocity

accept … × speed ***or*** *any transposed version*

1

(ii) 11.2 to 11.3

0.75 × 15 for ***1*** *mark*

2

kg m/s down(wards) **or** Ns down(ward)

n.b. both unit ***and*** *direction required for this mark*

1

(iii) 11.2 to 11.3

accept same numerical answer as part (a)(ii)

accept answer without any unit ***or*** *with the same unit as in part (a)(ii), even if incorrect, but any other unit cancels the mark*

1

(iv) $\text{force} = \frac{\text{change in momentum}}{\text{time}}$

accept transposed version

1

(v) 112 to 113 **or** numerical value from (a)(ii) × 10

11.25 ÷ 0.1 ***or*** *(a)(ii) ÷ 0.1 for* ***1*** *mark*

2

newton(s)

or *N*

accept Newton(s)

do ***not*** *credit 'Ns'* ***or*** *n*

1

(b) (the user will experience a) large change in momentum

*do **not** credit just '… momentum changes'*

1

(but) seat belt increases the time for this to occur **or**
seat belt stops you hitting something which would stop you quickly

*do **not** credit just '… stops you hitting the windscreen etc.'*

1

(so) the force on the user is less(*)

1

(so) less chance of (serious / fatal) injury(*)

(*) depends on previous response re momentum or continued movement

1

[13]

M4. (a) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

1

(ii) an external force acts (on the colliding objects)

accept colliding objects are not isolated

1

(b) (i) 9600

*allow **1** mark for correct calculation of momentum before or after*

ie 12000 or 2400

or

correct substitution using change in velocity = 8 m/s

ie 1200 × 8

2

kg m/s

this may be given in words rather than symbols

or

Ns

1

(ii) 3 or their (b)(i) ÷ 3200 correctly calculated

*allow **1** mark for stating momentum before = momentum after*

or

clear attempt to use conservation of momentum

2

[7]

M5. (i) momentum (change in) = mass × velocity (change in)

accept ... speed

1

(ii) 9000

*1500 × 6 for 1 mark but **not** from incorrect equation*

2

kilogram metre(s) per second **or** kg m/s

1

(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 ÷ 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)

3

[7]

M6. (a) (i) 210

*allow **1** mark for correct substitution i.e. 35 × 6*

2

kg m/s **or** Ns

*do **not** accept n for N*
*accept 210 000g m/s for **3** marks*

1

(ii) 840

if answer given is not 840 accept their (a)(i) in kg m/s ÷ 0.25 correctly calculated for both marks

*allow **1** mark for correct substitution i.e. 210 ÷ 0.25 or their (a)(i) ÷ 0.25*

2

(b) increases the time to stop

accept increases impact time
*do **not** accept any references to slowing down time*

1

decreases rate of change in momentum

accept reduces acceleration/deceleration
reduces momentum is insufficient

1

reduces the force (on the child)

1

(c) any **two** from:

- insufficient range of tests/thicknesses for required cfh

  accept need data for thicknesses above 80 mm/ cfh 2.7 m
  not enough tests is insufficient

- (seems to be) some anomalous data

- (repeats) needed to improve reliability (of data)

  accept data/ results are unreliable
  *do **not** accept maybe systematic/random error*
  *do **not** accept reference to precision*

- need to test greater range/variety of dummies

  accept children for dummies
  accept specific factor such as weight/height/size

2

(d) Tyres do not need to be dumped/burned/ less land-fill/ saves on raw materials

accept less waste
*do **not** accept recycling on its own*

1

[11]

M7. (a) 4 (m/s)

***1** mark for correct transformation of either equation*
***1** mark for correct substitution with or without transformation*
***1** mark for correct use of 0.6N*

*max score of **2** if answer is incorrect*

3

(b) **greater** change in momentum

or greater mass of air (each second)

or increase in velocity of air

accept speed for velocity

force upwards increased

lift force is increased

*do **not** accept upthrust*

1

or force up greater than force down

accept weight for force down

1

(c) • increase the time **to stop**

1

• decrease rate of change in momentum or same momentum change

accept reduced deceleration/ acceleration

1

• reducing the force on the toy

*do **not** accept answers in terms of the impact/ force being absorbed*

*do **not** accept answers in terms of energy transfer*

*do **not** credit impact is reduced*

1

[8]

M8. (a) (i) linear scales used

do not credit if less than half paper used

1

points plotted correctly

all of paper used

1

(straight) line of best fit drawn

allow a tolerance of ± half square

1

(ii) correct **and** straight line through origin

***all** needed*

e.c.f. if their (a)(i) is straight but not through the origin - incorrect because line does not go through origin

credit a calculation that shows proportionality

1

(iii) 62 ± 0.5 (m)

*credit **1** mark for KE = 490000 **or** 490kJ*

*credit **1** mark for correct use of graph clearly shown*

2

(iv) any **one** from: wet **or** icy **or** worn **or** smooth road

accept slippery slope

brakes worn

accept faulty brakes

car heavily loaded
worn tyres
downhill slope

do not accept anything to do with thinking distance e.g. driver tired or drunk

1

(b) (i) acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$

accept correct transformation

accept $\frac{v-u}{t} = a$

accept $m/s^2 = \frac{m/s}{s}$

*do **not** accept acceleration =* $\frac{\text{velocity}}{\text{time}}$

1

(ii) 56

accept –56

1

(iii) deceleration is reduced

accept deceleration is slower

accept acceleration

1

<u>force</u> on car and or passengers is reduced

accept an answer in terms of change in momentum for full credit

1

[11]

M9. (a) (i) B unless unqualified

for 1 mark

1

(ii) B unless unqualified

for 1 mark

1

(iii) energy lost, doing work against
air resistance/friction

for 1 mark

1

(b) intensity of gravity less (not zero)

for 1 mark

energies/restoring forces less

for 1 mark

2

[5]

M10. (a) there is a (maximum) forward force
drag/friction/resistance (**opposes** motion) (**not** pressure)
increases with speed
till forward and backward forces equal
so no net force/acceleration

any 4 for 1 mark each

4

(b) (i) F = ma
10 000 = 1250a
a = 8
m/s^2

for 1 mark each

4

(ii) ke = 1/2 mv^2
ke = 1/2 1250.48^2
ke = 1 440 000
J

for 1 mark each

4

(iii) W = Fd
W = 10 000.144
W = 1 440 000
J

for 1 mark each

4

[16]

M11. (a) W = 65 × 10

(*allow* a maximum of 3 marks if candidate uses g = 9.8N / Kg (as ecf))

gains 1 mark

but

W = 650 (N)

(*allow* use of p.e.= m × g × h)

gains 2 marks

but

PE change = 650 × 1.25 **or** 65 × 10 × 1.25

gains 3 marks

but

PE change = 812.5 (J) (*allow* 813J or 812J)

gains 4 marks

4

(b) k.e. = p.e.

gains 1 mark

but

$(speed)^2$ = 812.5 × 2 / 65 **or** 812.5 = ½ × 65 × $(speed)^2$ ecf

gains 2 marks

but

speed = 5 (m/s) (*allow* 4.99 → 5.002)

(if answer = 25mls check working: 812.5 = ½ m × v gains 1 mark for KE = PE)

(but if 812.5 = ½m × v^2 = ½ × 65 × v^2 or $v^2 = \frac{2 \times 812.5}{65}$ gains 2 marks)

25, with no working shown gains 0 marks

gains 3 marks

3

[7]

M12. (a) the greater the mass / weight

1

then the greater the <u>kinetic energy</u>

accept the greater the momentum

accept greater mass / weight therefore greater force = 2

1

(b) (i)

<u>*Note: this calculation requires candidates to show clearly how they work out their answer*</u>

k.e. $\frac{1}{2}$ mv^2

accept evidence of equation

1

86 400 (J) at 12 m/s

*accept ½ × 1200 × 12^2 **or** 86.4 KJ*

1

194 400 (J) at 18 m/s

*accept ½ × 1200 × 18^2 **or** 194.4KJ*

1

increase in k.e. = 108 000

NB 10800 = 0 marks

N.B. if no working at all then max 3 for a correct numerical answer

1

joules **or J**

*accept 108 kilojoules **or** kJ*

1

(ii) explanation that ke $\propto$ v^2

1

[8]

M13. (a) 47250

*answers of 1350/ 33750/ 48600 gain **1** mark*
*allow **1** mark for correct substitution using both 18 and 3*

2

(b) (i) 47250 or their (a)

accept statement 'same as the KE (lost)'

ignore any units

1

(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*

1

[4]