Mark schemes

1 (a) increases

1

increases

1

(b) 23 (m)

*accept 43 circled for **1** mark*
*accept 9 + 14 for **1** mark*

2

(c) (i) all points correctly plotted

all to ± ½ small square
*one error = **1** mark*
*two or more errors = **0** marks*

2

line of best fit

1

(ii) correct value from their graph (± ½ small square)

1

(d) (i) 70

*½ × 35 × 4 gains **2** marks*
*attempt to estimate area under the graph for **1** mark*

3

(ii) line from (0.6,35)

1

sloping downwards with a less steep line than the first line

1

cutting time axis at time > 4.6 s

accept cutting x-axis at 6

1

(e) (i) 42 000

*1200 × 35 gains **1** mark*

2

kgm / s

Ns

1

(ii) 10 500 (N)

*42 000 / 4 gains **1** mark*

alternatively:

$a = 35 / 4 = 8.75\ m / s^2$

$F = 1200 \times 8.75$

2

[19]

2 (a) Zero / 0

Accept none

Nothing is insufficent

1

velocity / speed = 0

accept it is not moving

paintball has not been fired is insufficient

1

(b) 0.27

*allow **1** mark for correct substitution, ie p = 0.003(0) × 90 provided no subsequent step*

2

(c) equal to

1

[5]

3 (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]

4 (a) any **two** from:

- (make shape / body) more streamlined

  accept a correct description
  accept lower the seating position of the driver

- increase power of engine

  faster engine is insufficient

- reduce mass / weight (of go-kart)

  change wheel size is insufficient

2

(b) (i) A–B

reason only scores if A–B is chosen

1

steepest / steeper gradient / slope

1

(iii) 1820

*allow **1** mark for correct substitution, ie 140 × 13 provided no subsequent step shown*

2

[6]

5 (a) **D – E**

reason only scores if D – E chosen

1

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) 80 000

*allow **1** mark for correct substitution, ie 16 000 × 5 provided no subsequent step shown*

2

(c) (i) straight line starting at origin

accept within one small square of the origin

1

passing through t = 220 and d = 500

1

(i) 186

accept any value between 180 and 188
accept where their line intersects given graph line correctly read ±4 s

1

[7]

6 (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]

7 (a) 98

*allow **1** mark for correct substitution*
ie ½ × 0.16 × 35 × 35 provided no subsequent step shown
an answer of 98 000 scores 0

2

(b) (i) 9.6

*allow **1** mark for (change in velocity =) 60*
ignore negative sign

2

(ii) 9600

ignore negative sign
or
their (b)(i) ÷ 0.001 correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

to reduce/change <u>momentum</u> (to zero)

only scores if 1st mark scored
decreases rate of change of momentum scores both marks provided there are no contradictions
accept decreased acceleration/deceleration
equations on their own are insufficient

1

[7]

8 (a) (moving in) different / opposite directions

accept one has positive momentum the other negative momentum

accept they have different velocities

1

(b) (i) momentum before = momentum after

or

(total) momentum stays the same

accept no momentum is lost

accept no momentum is gained

1

(ii) 2.2

*allow **1** mark for calculation of teenagers' momentum as 22 (kgm/s) and*

*allow **1** mark for correct statement, eg momentum before = momentum after*

or

*allow **2** marks for a numerical expression of above, eg*

55 × 0.4 = m × 10

***or** 0 = (55 × 0.4) + (m × (-10))*

3

(c) any **two** from:

- work is done
- (against) friction

  any reference to increasing friction negates this marking point
- (transforming) (kinetic) energy into heat

2

[7]

9 (a) (i) 16 000

*allow **1** mark for correct substitution ie 3200 × 5*

2

(ii) 16 000 or their (a)(i)

1

(iii) less than

1

(b) increases

1

decreases

correct order only

1

[6]

10 (a) direction

1

(b) 54 000

*allow **1** mark for calculating and identifying momentum as 10 800*

or

*allow **1** mark for correct substitution into second equation*

ie $\frac{1200 \times 9}{0.2}$

2

(c) increases the time taken (for head) to stop

accept increases impact time

*do **not** accept reference to slowing down time unless qualified*

1

decreases rate of change in momentum

accept reduces acceleration / deceleration

*accept increases the time taken to reduce momentum to zero is worth **2** marks*

reduces momentum is insufficient

1

reduces the force (on the head)

1

[6]

11 (a) (i) lorry

reason only scores if lorry chosen

1

greatest mass

accept weight for mass

accept heaviest

accept correct calculations for all 3 vehicles

the biggest is insufficient

1

(ii) 2450

*allow **1** mark for correct substitution*

ie 175 × 14

2

(b) (i) increases

accept any clear indication of the correct answer

1

(ii) speed increases

accept velocity for speed

accept gets faster

*do **not** accept it accelerates on its own*

moves more is insufficient

1

(iii) straight line going to 6, 20

*allow **1** mark for a curve going to 6,20*

***or** a straight line diagonally upwards but missing 6,20*

2

horizontal line from 6,20 to 8,20

*allow a horizontal line from where their **diagonal** meets 20m/s to 8,20*

1

[9]

12 (a) 4.2

*2 marks for correct substitution **and** transformation, ie 1155/275*

*allow **1** mark for correct resultant force with a subsequent incorrect method, ie 1155*

*allow **1** mark for an incorrect resultant force with a subsequent correct method,*

*eg answers of 7.27 or 10.34 gain **1** mark*

3

(b) (i) YES

marks are for the explanation

any **two** from:

- data (from police files) can be trusted
- data answers the question asked

  allow a conclusion can be made from the data
- large sample used

NO

any **two** from:

- the sample is not representative
- the sample size is too small
- accident files do not indicate age / experience of riders

  *an answer YES and NO can score **1** mark from each set of mark points*

2

(ii) more accidents with motorbikes up to 125 cc

*accept for **2** marks an answer in terms of number of under 125 cc to accidents ratio compared correctly with number of over 500 cc to accidents ratio*

1

even though there are fewer of these bikes than bikes over 500 cc

1

(c) (i) increases the time taken to stop

accept increases collision time

1

decreases rate of change in momentum

accept reduces acceleration / deceleration

accept $F = \frac{\Delta mv}{\Delta t}$

reduces momentum is insufficient

1

reduces the force (on the rider)

1

(ii) YES

any sensible reason, eg:

the mark is for the reason

- cannot put a price on life / injury
  accept may save lives
- fewer (serious) injuries
  accept reduces risk of injury
- reduces cost of health care / compensation

NO

any sensible suggestion, eg:

- money better spent on …
  needs to be specific
- total number of riders involved is small

1

[11]

13 (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]

14 (a) (i) 10800

allow 1 mark for correct substitution i.e. 900 × 12

2

(ii) arrow pointing towards the left

allow anywhere on the diagram or at bottom of the page

1

(b) zero

accept 0 / none / nothing

1

velocity is zero

accept speed for velocity

accept stopped / not moving

accept a calculation i.e. 900 × 0 = 0

1

[5]

15 (a) (i) 4.5

*allow **1** mark for correct substitution i.e. 9 ÷ 2*

2

(ii) m/s^2

accept answer given in (a)(i) if not contradicted here

1

(iii) speed

1

(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*

1

smallest (impact) force

1

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

[10]

16 (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]

17 (a) (i) velocity includes direction

accept velocity is a vector

1

(ii) 64

*allow **1** mark for obtaining values of 16 and 4 from the graph*
***or** marking correct area or correct attempt to calculate an area*

2

(iii) any **two** from:

- velocity zero from 0 to 4 seconds
- increasing in 0.2 s (or very rapidly) to 8 m/s
- decreasing to zero over the next 8 seconds

2

(iv) momentum before does not equal momentum after

ignore reference to energy

or total momentum changes

or an external force was applied

1

(b) to reduce the momentum of the driver

1

a smaller (constant) force would be needed

*do **not** accept reduces the impact / impulse on the driver*

1

[8]

18 (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]

19 (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]

20 (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) 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]

21 (a) (i) **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 total momentum after (the collision) equals the total momentum before (the collision) (2)

*accept 'momentum before equals momentum after' for **1** mark*

2

(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

1

(iii) momentum = mass × velocity **or** any correctly transposed version

accept momentum = mass × speed
accept p = mv
*do **not** accept momentum = ms*
or M = mv

1

(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) × v*

3

m/s

1

to the right

1

(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

1

(b) force = (change in) momentum ÷ time

or any correctly transposed version

1

4000 **or** 4 kilonewtons

dependent on correct or no equation
*force = 5 ÷ 0.00125 gains **1** mark*

2

[13]

22 (a) Total momentum (of a system of bodies) remains constant

accept momentum before (a collision) = momentum after (a collision)

1

Provided no external force acts

1

(b) (i) rotate the compressor

1

(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

4

(c) m = 350

answer 0.35 one mark only

*allow one mark if 105 000 **or** 475-175 **or** 300 have been used*

2

[9]

23 (a) (i) zero

accept nothing

1

speed is zero

accept not moving

1

(ii) A

1

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

(iv) kg m/s

1

[7]

24 (a) (i) direction indicated

*accept to right **or** + or – **or** arrow drawn on diagram*

1

300

1

kg m/s **or** Ns

1

(ii) 300 (kg m/s)

1

(b) momentum of person towards jetty = momentum of boat away from jetty
or total momentum is constant so as person goes one way boat goes the other

***1** mark is for the idea of momentum conservation*

***1** is for direction*

2

(c) time of collision increases

*do **not** accept momentum is conserved*

1

so a smaller force is exerted

*do **not** accept designed to absorb energy **or** momentum*

1

to produce the same change of momentum **or** impulse force

*do **not** accept cushions fall*

1

[9]

25 (a) the snow

1

smallest mass

*do **not** accept it is not moving*

accept weight for mass

accept it's the lightest

1

(b) (i) decrease

1

velocity reducing

accept speed for velocity

accept it is stopping

*do **not** accept the brakes are on*

accept car is decelerating

1

(ii) forwards

1

direction of momentum does not change
or the car stops and snow does not

dependent on forwards given

accept answers given in terms of Newton's second or first law of motion

accept momentum of snow

*do **not** accept the snow still has momentum*

1

(c) Ns

1

[7]

26 (a) (i) 6

for 1 mark

1

(ii) 6

for 1 mark

1

(iii) 1.5

for 1 mark

1

(iv) 4.5

for 1 mark

1

(v) 3

for 1 mark

1

(b) initial ke = 12J;

final ke = 0.75J + 6.75J;

energy loss = 4.5J

for 1 mark each

(If wrong; any correct ke value gains 1 mark; maximum of 2
path through calculation clear and correct gains 1 mark)
(ignore either ball – max 1 mark)

3

[8]

27 (a) Each scale optimum
Else both half size
Straight line joining 30,0 to 30,0.67 to 0, 5.67

any 5 for 1 mark each

5

(b) 6
Else a = 30/5
gets 2 marks

Else a = v/t
gets 1 mark

3

(c) 9000
Else F = 6 × 1500
gets 2 marks

Else F = ma
gets 1 mark

3

(d) (i) Driver has forward momentum
Which is conserved
Giving drive relative forward speed to car
for one mark each

3

(ii) Car stops in 75m
gets 1 mark

W = F.d or 9000 × 75
gets 1 mark

W = 675 000 J
OR ke = 1/2 mv^2
gets 1 mark

ke = 1/2.1500.302
ke = 675 000 J

3

[17]

28 (a) mass and velocity/speed multiplied
for 1 mark each

2

(b) total momentum before and after collision are the same
for 1 mark each

2

(c) (i) $M_AU_A + M_BU_B = (M_A + M_B)v$
$2 \times 6 = (2 + 1)v$
$v = 4$
m/s
for 1 mark each

4

(ii) 1/2 mv^2 (before) – 1/2 mv^2 (after) 1/2 2.36 – 1/2 3.16 = 12
J
for 1 mark each

4

[12]

29 (a) Throughout the question the equation M = mv is credited once only. This is the first time it appears. The mark scheme below assumes it will appear in (i).

(i) M = mv m × v sufficient **not** m × s, mass × speed
= 1500 × 8
= 12 000
(see marking of calculations)

3

(ii) M = mv
M = 2000 × 1 = 2000
(see marking of calculations)

2

(iii) must be sum of (i) and (ii) 14 000
for 1 mark

1

(b) total mass = 3500
momentum = 14 000 (conserved)
M = mv **or** v = 14 000/3500
v = 4
m/s

5

(c) (i) it reduces

for 1 mark

1

(ii) ke to sound/heat

for 1 mark

1

[12]

30 (a) product of mass and velocity

1

(b) (i) 4kg or 4000g

1

(ii) M = 8kgm/s or Ns

for 3 marks

else M = 8

for 2 marks

else M – mv or 4 × 2

for 1 mark

3

(iii) 8 kgm/s (watch e.c.f.)

1

(iv) v = 400

for 3 marks

else v = 8/0.02

for 2 marks

else M – mv, v – M/m or 8 = 0.02v

for 1 mark

3

(v) ke = 8

for 3 marks

else ke = 1/2 (4×2^2)

for 2 marks

else ke = 1/2 (mv^2)

for 1 mark

3

(vi) transferred to heat and sound
or does work against wood/pushing wood aside/deforming bullet

1

[13]

31 (a) WX deceleration / speed decreasing / slowing down / negative acceleration

XY constant speed / steady speed *not* constant motion / slow speed

YZ acceleration / speed increasing / speeding up

for 1 mark each

3

(b) distance = v × t **or** distance = 30 × 20

gains 1 mark

but
distance = 600(m)

gains 2 marks

2

(c) acceleration = v / t **or** acceleration = 30 / 12

gains 1 mark
(if –30 / 12, allow negative sign here if not in the answer)

3

but
acceleration = 2.5 (m/s^2)

gains 2 marks

but
acceleration = -2.5 (m/s^2)

gains 3 marks

(d) in a crash / during hard braking car body stops / slows rapidly driver / passengers continue to move forward *not* thrown forward seatbelts provide backward force / keep them in their seats / restrain them to stop them hitting the windscreen / dashboard

(an alternative argument involving momentum is acceptable)
for 1 mark each

4

[12]

32 (a) *ideas that* greater speed means more kinetic energy

gains 1 mark

but *any evidence of the formula* ½ mv^2

but making the case that kinetic energy depends on the speed squared

gains 3 marks

or that $2^2 = 4$

3

(b) (i) any evidence of concept of momentum or mass × speed (or velocity) in words or figures e.g. 9.5 × 20 **or** 0.5 × 40

gains 1 mark

but correct values for momentum of lorry and car
i.e. 190 and 20 [ignore units]

gains 2 marks

but initial momentum correctly calculated
170 or 190 – 20

gains 3 marks

THEN
evidence when calculating final speed of
idea that momentum is conserved
use of combined mass

each gain 1 mark

but
17 [or 0.1 × figure for initial momentum]
(NB direction <u>not</u> required)

gains 3 marks

6

(ii) <u>kinetic</u> energy is lost

for 1 mark

[*credit* (some kinetic) energy transferred as heat/sound]
[NB Accept only answers in terms of energy as required by the question]

1

[10]