Mark schemes

1

(a) **Level 2 (3–4 marks):**
A detailed and coherent description of a plan covering all the major steps is provided. The steps are set out in a logical manner that could be followed by another person to obtain valid results.

Level 1 (1–2 marks):
Simple statements relating to relevant apparatus or steps are made but they may not be in a logical order. The plan would not allow another person to obtain valid results.

0 marks:
No relevant content.

Indicative content

- measure the distance the ruler falls before being stopped
- the greater this distance the greater the reaction time
- repeat measurements and calculate a mean
- repeat several times with the student listening to music (through earphones). Calculate a mean.
- a (significant) difference between the two means would show that music affects reaction time.

4

(b) reaction time decreases with practice

allow Y has a shorter reaction time

1

allow Y has faster reaction times (than X)

(c) the stop clock was started before the computer test started

1

the student was distracted

1

[7]

2

(a) D

1

(b) C

1

(c) W = 300 × 45

1

W = 13 500

1

*allow 13 500 with no working shown for **2** marks*

(d) straight line drawn from 13 m / s to 0 m / s

1

finishing on x-axis at 65 s

1

[6]

3 (a) Third Law

1

(b) elastic potential

1

(c) weight = mass × gravitational field strength

accept gravity for gravitational field strength

1

accept W = mg

accept correct rearrangement ie mass = weight / gravitational field strength ***or*** *m = W / g*

(d) 343 = m × 9.8

1

$m = \frac{343}{9.8}$

1

m = 35

1

allow 35 with no working shown for ***3*** *marks*

(e) force = spring constant × compression

accept force = spring constant × extension

accept F = k e

accept correct rearrangement ie constant = force / extension ***or*** *k = F / e*

1

(f) compression = 0.07m

1

343 = k × 0.07

1

k = 343 ÷ 0.07

1

k = 4900

1

allow 4900 with no working shown for ***4*** *marks*

allow 49 with no working shown for ***3*** *marks*

[11]

4 (a) It will have a constant speed.

1

(b) distance travelled = speed × time

1

(c) $a = \frac{18 - 9}{6}$

1

$a = 1.5$

*allow 1.5 with no working shown for **2** marks*

1

(d) resultant force = mass × acceleration

1

(e) $F = (1120+80) \times 1.5$

1

$F = 1800$ (N)

*allow 1800 with no working shown for **2** marks*

1

*accept their 10.3 × 1200 correctly calculated for **2** marks*

(f) $18^2 - 9^2 = 2 \times 1.5 \times s$

1

$s = 18^2 - 9^2 / 2 \times 1.5$

1

$s = 81$ (m)

1

*allow 81 (m) with no working shown for **3** marks*

*accept answer using their 10.3 (if not 1.5) correctly calculated for **3** marks*

(g) **Level 2 (3–4 marks):**
A detailed and coherent explanation is provided. The response makes logical links between clearly identified, relevant points that include references to the numerical factor.

Level 1 (1–2 marks):
Simple statements are made. The response may fail to make logical links between the points raised.

0 marks:
No relevant content.

Indicative content

- doubling speed increase the kinetic energy
- kinetic energy increases by a factor of 4
- work done (by brakes) to stop the car increases
- work done increases by a factor of 4
- work done is force × distance and braking force is constant
- so if work done increases by 4 then the braking distance must increase by 4

4

[14]

5

(a) any sensible suggestion eg

- theory supported by results from other experiments
- could not believe the 'theory' could be wrong
- 'theory' is the basis of many other ideas

1

(b) any **two** from:

- to allow peer review of data
- to assess the reproducibility of the data
- to promote further enquiry / experiments
- to encourage other scientists to develop explanations / new theories

2

(c) 730 000 = 300 007 400 × time

1

$$\text{time} = \frac{730\,000}{300\,007\,400}$$

*this step without the previous step stated gains **2** marks*

1

$2.43(3273) \times 10^{-3}$ s

accept 0.00243(3273) s

1

*allow 2.43(3273) × 10^{-3} with no working for **4** marks*

(d) 60×10^{-9} s

1

(e) systematic error

1

(f) add on 60 nanoseconds to each time recorded (then recalculate)

1

[9]

6

(a) distance is a scalar and displacement is a vector

or

distance has magnitude only, displacement has magnitude and direction

1

(b) 37.5 km

accept any value between 37.0 and 38.0 inclusive

1

062° or N62°E

accept 62° to the right of the vertical

1

accept an angle in the range 60° −64°

accept the angle correctly measured and marked on the diagram

(c) train changes direction so velocity changes

1

acceleration is the rate of change of velocity

1

(d) number of squares below line = 17

accept any number between 16 and 18 inclusive

1

each square represents 500 m

1

distance = number of squares × value of each square correctly calculated − 8500 m

1

[8]

7

(a) the distance travelled under the braking force

1

(b) the reaction time will increase

1

increasing the thinking distance (and so increasing stopping distance)

(increases stopping distance is insufficient)

1

(c) No, because although when the speed increases the thinking distance increases by the same factor the braking distance does not.

1

eg

increasing from 10 m / s to 20 m / s increases thinking distance from 6 m to 12 m but the braking distance increases from 6 m to 24 m

1

(d) If the sled accelerates the value for the constant of friction will be wrong.

1

(e) only a (the horizontal) component of the force would be pulling the sled forward

1

the vertical component of the force (effectively) lifts the sled reducing the force of the surface on the sled

1

(f) $-u^2 = 2 \times -7.2 \times 22$

award this mark even with 0^2 and / or the negative sign missing

1

$u = 17.7(99)$

1

18

1

*allow 18 with no working shown for **3** marks*

*allow 17.7(99) then incorrectly rounded to 17 for **2** marks*

[11]

8 (a) the forces are equal in size and act in opposite directions

1

(b) (i) forwards / to the right / in the direction of the 300 N force

answers in either order

1

accelerating

1

(ii) constant velocity to the right

1

(iii) resultant force is zero

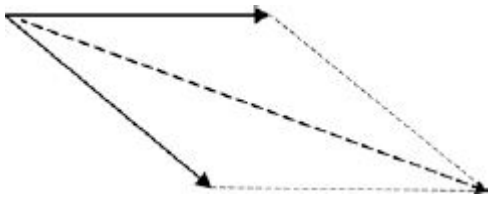
accept forces are equal / balanced

1

so boat continues in the same direction at the same speed

1

(iv) parallelogram or triangle is correctly drawn with resultant



3

value of resultant in the range 545 N – 595 N

*parallelogram drawn without resultant gains **1** mark*

If no triangle or parallelogram drawn:

*drawn resultant line is **between** the two 300 N forces gains **1** mark*

*drawn resultant line is between and longer than the two 300 N forces gains **2** marks*

1

[10]

9

(a) terminal

1

(b) 5.4 (kg)

*correct substitution of 54 = m × 10 gains **1** mark*

2

(c) (i) 0< a <10

1

some upward force

accept some drag / air resistance

1

reduced resultant force

1

(ii) 0

1

upward force = weight (gravity)

1

resultant force zero

1

[9]

10

(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]

11 (a) (i) 100 (m)

1

(ii) stationary

1

(iii) accelerating

1

(iv) tangent drawn at $t = 45$ s

1

attempt to determine slope

1

speed in the range 3.2 – 4.2 (m / s)

dependent on 1st marking point

1

(b) (i) 500 000 (J)

ignore negative sign

1

(ii) 20 000 (N)

ignore negative sign

*allow **1** mark for correct substitution, ie*

500 000 = F × 25

***or** their part (b)(i) = F × 25*

provided no subsequent step

2

(iii) *(kinetic) energy* transferred by heating

1

to the brakes

ignore references to sound energy

*if no other marks scored allow k.e. decreases for **1** mark*

1

[11]

12 (a) pitch

1

loudness

1

(b) (i) as length (of prongs) decreases frequency / pitch increases

accept converse

accept negative correlation

ignore inversely proportional

1

(ii) 8.3 (cm)

accept 8.3 ± 0.1 cm

1

(iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)

*ecf from part **(ii)***

1

(so *f* must be) between 384 (Hz) and 480 (Hz)

1

410 (Hz) ≤ *f* ≤ 450 (Hz)

*if only the estimated frequency given, accept for **1** mark an answer within the range*

1

(c) (i) electronic

1

(ii) frequency is (very) high

accept frequency above

*20 000 (Hz) **or** audible range*

1

so tuning fork ***or*** length of prongs would be very small (1.2 mm)

1

(d) 285.7 (Hz)

accept any correct rounding 286, 290, 300

*allow **2** marks for 285*

*allow **2** marks for correct substitution 0.0035 = 1 / f*

*allow **1** mark for T = 0.0035 s*

*allow **1** mark for an answer of 2000*

3

[13]

13 (a) (i) not moving

1

(ii) straight line from origin to (200,500)

ignore a horizontal line after (200,500)

1

(b) 35 000

*allow **1** mark for correct substitution, ie 14 000 × 2.5 provided no subsequent step*

an answer of 87 500 indicates acceleration (2.5) has been squared and so scores zero

2

[4]

14 (a) (i) friction

1

(ii) air resistance

accept drag

friction is insufficient

1

(iii) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1–2 marks)
There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points
or
a description of how the velocity changes between any two points.

Level 2 (3–4 marks)
There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z
or
a complete description of how the velocity changes from X to Z.
or
an explanation and description of velocity change for either X to Y or Y to Z

Level 3 (5–6 marks)
There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z
and
a description of the change in velocity between X and Z.

examples of the points made in the response

extra information

X to Y

- at X force A is greater than force B
- cyclist accelerates
- and velocity increases
- as cyclist moves toward Y, force B (air resistance) increases (with increasing velocity)
- resultant force decreases
- cyclist continues to accelerate but at a smaller value
- so velocity continues to increase but at a lower rate

Y to Z

- from Y to Z force B (air resistance) increases
- acceleration decreases
- force B becomes equal to force A
- resultant force is now zero
- acceleration becomes zero

- velocity increases until…
- cyclist travels at constant / terminal velocity

accept speed for velocity throughout

6

(b) (i) 3360

*allow **1** mark for correct substitution,*
ie 140 × 24 provided no subsequent step
*accept 3400 for **2** marks if correct substitution is shown*

2

joule / J

*do **not** accept j*
*do **not** accept Nm*

1

(ii) decreases

accept an alternative word / description for decrease
do not accept slows down

1

temperature

accept thermal energy
accept heat

1

[13]

15 (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$

provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

16 (a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  *do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

*$1.5 \times 10^{3} = 2.0 \times 10^{6} \times \lambda$ gains **1** mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

allow amplitude / energy has decreased
allow the beam is weaker

2

[8]

17 (a) (i) 9.5

accept ±1 mm

1

10.5

1

(ii) 9.5

*ecf from **(a)(i)***

1

(iii) 190

*20 × **(a)(ii)** ecf*

1

(iv) medium

*ecf from **(a)(iii)***

1

(b) (i) any **two** from:

- position of ball before release
- same angle **or** height of runway
- same ball
- same strip of grass

2

(ii) long
or
longer than in part **(a)**
or
uneven

*do **not** allow reference to speed*

1

(c) (i) as humidity increases mean distance decreases

accept speed for distance

1

(ii) 71 × 180 = 12780
79 × 162 = 12798
87 × 147 = 12789
*all three calculations correct with a valid conclusion gains **3** marks*

or
find k from R = k / d
*all three calculations correct gains **2** marks*

or
87 / 71 × 147 = 180.1 ~ 180
87 / 79 × 147 = 161.9 ~ 162
*two calculations correct with a valid conclusion gains **2** marks*

conclusion based on calculation
*one correct calculation of k gains **1** mark*

3

(iii) only three readings **or** small range for humidity
accept not enough readings
accept data from Internet could be unreliable
ignore reference to repeats

1

(d) distance is a scalar **or** has no direction **or** has magnitude only
allow measurements from diagram of distance and displacement

1

displacement is a vector **or** has direction

1

[15]

18 (a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)
*do **not** accept region*

1

(iii) starts at same y−intercept

1

steeper slope than original and cuts time axis before original
the entire line must be below the given line
allow curve

1

(c) (i) 31
and
31

*correct answers to 2 significant figures gains **3** marks even if no working shown*

*both values to more than 2 significant figures gains **2** marks:*
30.952……
30.769….

65 / 2.1 and / or
*80 / 2.6 gains **1** mark*

*if incorrect answers given but if both are to 2 significant figures allow **1** mark*

3

(ii) student 1 incorrect because 80 ≠ 65

1

student 2 correct because average velocities similar

*ecf from **(c)(i)***

1

student 3 incorrect because times are different

1

[12]

19 (a) time

correct order only

1

force

1

(b) The car tyres being badly worn

1

(c) (i) braking distance increases with speed

accept positive correlation

*do **not** accept stopping distance for braking distance*

1

relevant further details, eg

- but not in direct proportion
- and increases more rapidly after 15 m/s

accept any speed between 10 and 20

accept numerical example

- double the speed, braking distance increases × 4

1

(ii) line drawn above existing line starting at the origin

as speed increases braking distance must increase
each speed must have a single braking distance

1

(d) (i) reaction time / reaction (of driver) does not depend on speed (of car)

1

(ii) (on the reduced speed limit roads) over the same period of time

accept a specific time, eg 1 year

1

monitor number of accidents before and after (speed limit reduced)

*allow **1** mark only for record number of vehicles / cars using the (20 mph) roads **or** collect data on accidents on the (20 mph) roads*

to score both marks the answer must refer to the roads with the reduced speed limit

1

[9]

20 (a) (produces) a force from water on the boat

1

in the forward direction

accept in the opposite direction

this must refer to the direction of the force not simply the boat moves forwards

*an answer produces an (equal and) opposite force gains **1** mark*

1

(b) (i) 1.5

*allow **1** mark for correct substitution, ie* $\frac{16-4}{8}$ ***or*** $\frac{12}{8}$

provided no subsequent step shown

ignore sign

2

m/s^2

1

(ii) 102

or

their (b)(i) × 68 correctly calculated

*allow **1** mark for correct substitution, ie 1.5 × 68*

***or** their (b)(i) × 68*

provided no subsequent step shown

2

(iii) greater than

reason only scores if greater than chosen

1

need to overcome resistance forces

accept named resistance force

accept resistance forces act (on the water skier)

*do **not** accept gravity*

1

[9]

21 (a) (i) distance vehicle travels during driver's reaction time

accept distance vehicle travels while driver reacts

1

(ii) any **two** from:

- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age

accept as an alternative factor distractions, eg using a mobile phone

2

(b) (i) 320 000

*allow **1** mark for correct substitution, ie* $\frac{1}{2} \times 1600 \times 20^2$ *provided no subsequent step shown*

2

(ii) 320000 **or** their (b)(i)

1

(iii) 40

or

$\frac{\text{their (b)(ii)}}{8000}$ correctly calculated

*allow **1** mark for statement work done = KE lost*

or

*allow **1** mark for correct substitution, ie*
*8000 × distance = 320 000 **or** their (b)(ii)*

2

(iv) any **one** from:

- icy / wet roads
  accept weather conditions
- (worn) tyres
- road surface
- mass (of car and passengers)
  accept number of passengers
- (efficiency / condition of the) brakes

1

(v) (work done by) friction
(between brakes and wheel)
*do **not** accept friction between road and tyres / wheels*

1

(causes) decrease in KE and increase in thermal energy
accept heat for thermal energy accept
KE transferred to thermal energy

1

(c) the battery needs recharging less often
accept car for battery

1

or
increases the range of the car
*accept less demand for other fuels **or** lower emissions **or** lower fuel costs*
environmentally friendly is insufficient

as the efficiency of the car is increased
accept it is energy efficient

1

the decrease in (kinetic) energy / work done charges the battery (up)
accept because not all work done / (kinetic) energy is wasted

1

[14]

22 (a) 4 N to the right

1

(b) (i) bigger than

1

equal to

1

(ii) reduces it

1

increases air resistance / drag / force C

accept parachute has large(r) (surface) area

1

[5]

23 (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]

24 (a) gravitational / gravity / weight

*do **not** accept gravitational potential*

1

(b) accelerating

accept speed / velocity increases

1

the distance between the drops increases

1

but the time between the drops is the same

accept the time between drops is (always) 5 seconds
accept the drops fall at the same rate

1

(c) (i) any **one** from:

- speed / velocity
- (condition of) brakes / road surface / tyres
- weather (conditions)

accept specific examples, eg wet / icy roads

accept mass / weight of car friction is insufficient

reference to any factor affecting thinking distance negates this answer

1

(ii) 75 000

*allow **1** mark for correct substitution, ie 3000 × 25 provided no subsequent step shown*

***or** allow **1** mark for an answer 75*
***or** allow **2** marks for*
75 k(+ incorrect unit), eg 75 kN

2

joules / J

*do **not** accept j*

*an answer 75 kJ gains **3** marks*

for full marks the unit and numerical answer must be consistent

1

[8]

25 (a) more streamlined

accept decrease surface area

1

air resistance is smaller (for same speed)

accept drag for air resistance

friction is insufficient

1

so reaches a higher speed (before resultant force is 0)

ignore reference to mass

1

(b) (i) 1.7

*allow **1** mark for correct method, ie* $\frac{5}{3}$

***or** allow **1** mark for an answer with more than 2 sig figs that rounds to 1.7*
***or** allow **1** mark for an answer of 17*

2

(ii) 7.5

*allow **1** mark for correct use of graph, eg* $\frac{1}{2} \times 5 \times 3$

2

(iii) air (resistance)

accept wind (resistance)

drag is insufficient

friction is insufficient

1

[8]

26 (a) 96 (m)

1

(b) (i) similar shape curve drawn <u>above</u> existing line going <u>through (0,0)</u>

*allow **1** mark for any upward smooth curve or straight upward line <u>above</u> existing line going through (0,0)*

2

(ii) Rain on the road

1

(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

2

(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
  accept cannot tell which variable is affecting the drive (the most)
- cannot tell original contribution
- need to measure one (variable) on its own
  accept need to test each separately
- need to control one of the variables
  fair test is insufficient

2

[8]

27 (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]

28 (a) (i) longer reaction time

accept slower reactions

*do **not** accept slower reaction time unless qualified*

or

greater thinking distance

accept greater thinking time

or

greater stopping distance

accept greater stopping time

greater braking distance negates answer

1

(ii) lines / slopes have the same gradient

accept slopes are the same

or

velocity decreases to zero in same time / in 2.6 seconds

accept any time between 2.4 and 2.8

accept braking distances are the same

1

(iii) 12

*accept extracting both reaction times correctly for **1** mark (0.6 and 1.4)*

or

*time = 0.8 (s) for **1** mark*

*accept 0.8 × 15 for **2** marks*

*accept calculating the distance travelled by car **A** as 28.5 m*

or

*the distance travelled by car **B** as 40.5 m for **2** marks*

3

(b) **Z**

1

different force values give a unique / different resistance

*only scores if **Z** chosen*

*do **not** accept force and resistance are (directly) proportional*

*accept answers in terms of why either **X** or **Y** would not be best eg*

***X** – same resistance value is obtained for 2 different force values*

***Y** – all force values give the same resistance*

1

[7]

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

- (acceleration occurs when) the direction (of each capsule) changes
- velocity has direction
- acceleration is (rate of) change of velocity

2

(b) to(wards) the centre (of the wheel)

1

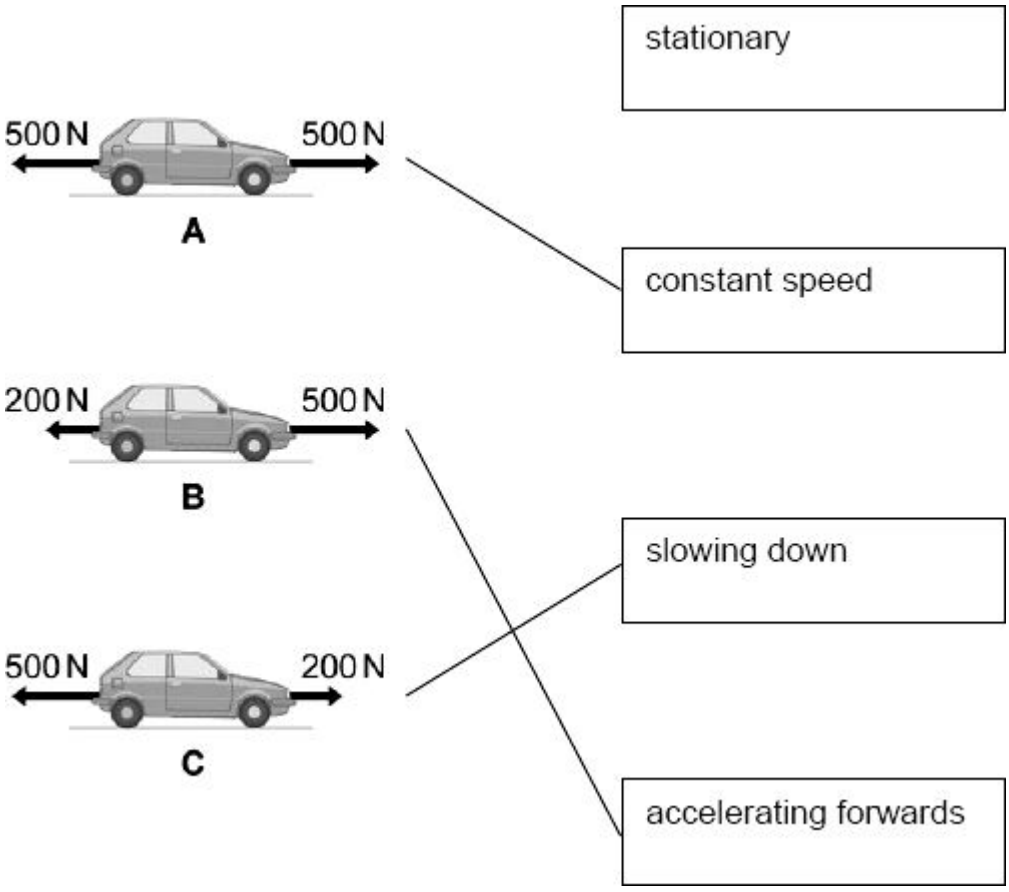
(c) the greater the radius / diameter / circumference (of the wheel) the smaller the (resultant) force (required)

accept 'the size' for radius
both parts required for the mark

1

[4]

30 (a) *3 lines drawn*
all correct
*allow **1** mark for each correct line*
if two or more lines are drawn from any diagram then all these lines are incorrect



3

(b) (i) horizontal arrow to the right

judge by eye
accept an arrow drawn outside the box if it is labelled correctly

1

(ii) horizontal arrow to the left

judge by eye

accept an arrow drawn outside the box if it is labelled correctly

1

(iii) equal to

1

(iv) to measure the forces exerted on the dummy during the impact

1

[7]

31 (a) **A** constant speed / velocity

accept steady pace

*do **not** accept terminal velocity*

*do **not** accept stationary*

1

B acceleration

accept speeding up

1

C deceleration

accept slowing down

accept accelerating backwards

accept accelerating in reverse

*do **not** accept decelerating backwards*

1

(b) (i) the distance the car travels under the braking force

accept braking distance

1

(ii) speed/velocity/momentum

1

(c) (i) 5000 (N) to the left

***both** required*

accept 5000(N) with the direction indicated by an arrow drawn pointing to the left

accept 5000(N) in the opposite direction to the force of the car (on the barrier)

accept 5000(N) towards the car

1

(ii) to measure/detect forces exerted (on dummy / driver during the collision)

1

(iii) 4

*allow **1** mark for showing a triangle drawn on the straight part of the graph*

***or** correct use of two pairs of coordinates*

2

m/s^2

*do **not** accept mps^2*

1

[10]

32 (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]

33 (a) (i) 3

1

(ii) 30 000 **or** 10 000 × their (a)(i) correctly calculated

1

(iii) any **two** from:

- frequency is above 20 000 (Hz)
  accept the frequency is 30 000
- frequency is above the upper limit of audible range
- upper limit of audible range equals 20 000 (Hz)
  ignore reference to lower limit
- it is ultrasound/ultrasonic

2

(b) (i) wave (partially) reflected

1

at crack to produce **A** and end of bolt to produce **B**
accept at both ends of the crack

1

(ii) 0.075 (m) allow **2** marks for time = 0.0000125
*allow **1** mark for time = 0.000025*
*answers 0.15 **or** 0.015 **or** 0.09 gain **2** marks*
*answers 0.18 **or** 0.03 gain **1** mark*
the unit is not required but if given must be consistent with numerical answer for the available marks

3

[9]

34 (a) 750
*allow **1** mark for correct substitution, ie 75 × 10 provided no subsequent step shown*

2

newton(s) / N
*do **not** accept n*

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.
Examiners should also refer to the Marking Guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a brief attempt to explain why the velocity / speed of the parachutist changes.
or
the effect of opening the parachute on velocity/speed is given.

Level 2 (3-4 marks)
The change in velocity / speed is clearly explained in terms of force(s)
or
a reasoned argument for the open parachute producing a lower speed.

Level 3 (5-6 marks)
There is a clear and detailed explanation as to why the parachutist reaches terminal velocity
and
a reasoned argument for the open parachute producing a lower speed

examples of the physics points made in the response to explain first terminal velocity

- on leaving the plane the only force acting is weight (downwards)
  accept gravity for weight throughout
- as parachutist falls air resistance acts (upwards)
  accept drag / friction for air resistance
- weight greater than air resistance
  or
  resultant force downwards
- (resultant force downwards) so parachutist accelerates
- as velocity / speed increases so does air resistance
- terminal velocity reached when air resistance = weight
  accept terminal velocity reached when forces are balanced

to explain second lower terminal velocity

- opening parachute increases surface area
- opening parachute increases air resistance
- air resistance is greater than weight

- resultant force acts upwards / opposite direction to motion
- parachutist decelerates / slows down
- the lower velocity means a reduced air resistance

air resistance and weight become equal but at a lower (terminal) velocity

6

(c) (i) any **one** from:

- mass of the (modelling) clay
  accept size/shape of clay size/amount/volume/shape of clay
  accept plasticine for (modelling)clay
- material parachute made from
  accept same (plastic) bag
- number / length of strings

1

(ii) **C**

*reason only scores if **C** is chosen*

1

smallest (area) so falls fastest (so taking least time)

accept quickest/quicker for fastest
*if **A** is chosen with the reason given as 'the largest area so falls slowest' this gains **1** mark*

1

[12]

35 (a) **B**

reason only scores if B is chosen

1

gradient / slope is the steepest / steeper

answers must be comparative
accept steepest line
ignore greatest speed

1

(b) (velocity includes) direction

'it' refers to velocity

1

[3]

36 (a) 2.75

*allow **1** mark for correct substitution, ie* $\frac{11}{4}$

or $\frac{23-12}{4}$

provided no subsequent step shown

2

m/s^2

1

(b) driving force increases

1

frictional force increases

accept air resistance / drag for frictional force

1

driving force > frictional force

1

[6]

37 (a) (i) 12

1

(ii) 0.2

*allow **1** mark for their (a)(i) ÷ 60 and correctly calculated*

1

m/s^2

accept correct unit circled in list

accept ms^{-2}

*do **not** accept mps^2*

1

(b) **B**

1

[4]

38 (a) (i) 120

1

(ii) 20

accept 140–their (a)(i) provided answer is not negative

1

(iii) as speed increases

1

drag force / water resistance / friction / **D** increases

1

(until) **D** = 140 N or (until) **D** = **T**

forces balance is insufficient

1

(b) (i) (average) speed (of swimmer)

1

(ii) any **two** from:

- more data
  accept results for data
  *do **not** accept more accurate data*
- force may vary (a lot) / change
- give more reliable average
  ignore references to anomalies
  ignore accurate / precise

2

(iii) examples of acceptable responses:

- most / some females produce smaller forces
  *do **not** accept all females produce smaller forces*
- most / some males produce larger forces
  *do **not** accept all males produce larger forces*
- some females swim as fast as males but use a smaller force
- most of the faster swimmers are male
  *do **not** accept all males swim faster*
- most of the slower swimmers are female
  *do **not** accept all females swim slower*
- range of the (average) speed of males is smaller than the range of the (average) speed of females
- range of the (average) force of the males is greater than the range of the (average) force of the females

1

(iv) exert maximum (hand) force (throughout the swim / stroke)

accept (any method to) increase (hand) force

practise more is insufficient

1

[10]

39 (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]

40 (a) The driver has been drinking alcohol.

reason only scores if this box is ticked

1

driver's reaction time increases

accept slower reactions

accept slower reaction time

or

thinking distance / stopping distance increases

do not accept braking distance increases

or

driver less alert

accept driver may fall asleep / be tired

1

(b) they are all variables that could affect outcome / results

accept specific effect of changing one of the variables

accept to make the test valid

ignore reliable

1

so data / barriers can be compared

accept to see which is / works best / safest

*do **not** accept fair test on its own*

1

(c) ticks in both the top and middle boxes

1

[5]

41 (a) 48

*allow for **1** mark correct method shown, ie 6 × 8*

***or** correct area indicated on the graph*

2

(b) diagonal line from (0,0) to (6,48) / (6, their (a))

if answer to (a) is greater than 50, scale must be changed to gain this mark

1

horizontal line at 48m between 6 and 10 seconds

accept horizontal line drawn at their (a) between 6 and 10 seconds

1

[4]

42 (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]

43 (a) 96

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

ie 80 × 1.2

2

newton or N

allow Newton

*do **not** allow n*

1

(b) (i) direction

1

(ii) velocity and time are continuous (variables)

answers must refer to both variables

accept the variables are continuous / not categoric

accept the data / 'it' is continuous

accept the data / 'it' is not categoric

1

(iii) **C**

1

velocity is not changing

*the **2** marks for reason may be scored even if **A** or **B** are chosen*

accept speed for velocity

accept speed is constant (9 m/s)

*accept **not** decelerating*

*accept **not** accelerating*

accept reached terminal velocity

1

forces must be balanced

accept forces are equal

accept arrows are the same length / size

or

resultant force is zero

*do **not** accept the arrows are equal*

1

[8]

44 (a) distance travelled under the braking force

accept braking (distance)

1

(b) (directly) proportional

accept a correct description using figures

or

increase in the same ratio

eg if speed doubles then

thinking distance doubles

*accept for **1** mark positive correlation*

*accept for **1** mark as speed*

increases so does thinking distance

accept as one increases the other increases

accept as thinking distance increases speed increases

2

(c) (i) control variable

1

(ii) experiment done, student listens to music / ipod (etc)

1

experiment (repeated), student not listening to music

for both marks to be awarded there must be a comparison

1

(d) increase it

accept an answer which implies reactions are slower

*do **not** accept answers in terms of thinking distance only*

1

(e) **Y**

1

[8]

45 (a) (i) longer reaction time

accept slower reactions

*do **not** accept slower reaction time unless qualified*

or

greater thinking distance

accept greater thinking time

or

greater stopping distance

accept greater stopping time

greater braking distance negates answer

1

(ii) lines / slopes have the same gradient

accept slopes are the same

or

velocity decreases to zero in same time / in 2.6 seconds

accept any time between 2.3 and 2.8

accept braking distances are the same

1

(iii) 12

*accept extracting both reaction times correctly for **1** mark*

*(0.6 and 1.4) **or** time = 0.8(s) for **1** mark*

*accept 0.8 × 15 for **2** marks*

accept calculating the distance

*travelled by car **A** as 28.5 m **or** the distance travelled by car **B** as 40.5 m for **2** marks*

3

(b) **Z**

1

different force values give a unique / different resistance

*only scores if **Z** chosen*

*do **not** accept force andresistance are (directly) proportional*

accept answers in terms of why

*either **X or Y** would not be the best eg*

***X** – same resistance value is obtained for 2 different force values*

***Y** – all force values give the same resistance*

1

[7]

46 (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]

47 (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

1

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

[8]

48 (i) the thicker the tile, the greater the *(*fall) height

accept the higher (the fall) the thicker the tile
accept there is a positive correlation
*do **not** accept they are proportional*

1

(ii) 60 (mm)

accept any number or range between 60 and 85 inclusive
if units are given must match range

1

(minimum thickness*)* needed to <u>reduce risk of injury</u>

reason must match thickness choice
*do **not** accept to keep child safe*

accept an answer in terms of – the thicker the tile, the less chance there is of a serious injury if the answer given is greater than 60

accept answers in terms of use of graph e.g. the graph shows that for a 2m fall a thickness of 60 mm is needed

minimum level answer' the graph shows that's what's needed'
accept only if 60 is the answer

1

[3]

49 (a) gravity

accept weight

*do **not** accept mass*

accept gravitational pull

1

(b) (i) Initially force L greater than force M

accept there is a resultant force downwards

1

(as speed increases) force M increases

accept the resultant force decreases

1

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*

1

(ii) terminal velocity

1

(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*

2

[7]

50 (a) (i) same frequency / period / pitch / wavelength

ignore references to amplitude

1

(ii) differences in waveform / shape / quality

accept the diagrams are not identical

1

(b) (i) 20 000 Hz / hertz

or 20 kHz / kilohertz

*in both cases, if the **symbol** rather than the name is used, it must be correct in every detail*

1

(ii) material(s) / substance(s) (through which sound travels)

1

(iii) is absorbed

accept (some) sound (energy) is transformed / transferred as heat / thermal energy

1

is transmitted

accept is refracted
accept changes speed
accept changes velocity

*do **not** accept is diffracted*
*do **not** accept is diffused*
*do **not** accept is dissipated*

1

[6]

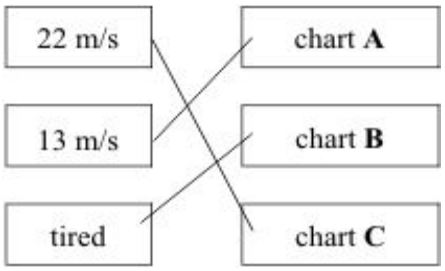
51 (a) (i) constant

1

(ii) heat

1

(b) (i) 3 links correct



*allow **1** mark for 1 correct link*

if more than one line is drawn from a condition mark all lines from that condition incorrect

2

(ii) increased

1

[5]

52 (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

1

(ii) constant speed (in a straight line)

*do **not** accept stationary*

or constant velocity

1

(b) 3

*allow **1** mark for correct substitution into transformed equation*
*accept answer 0.003 gains **1** mark*
*answer = 0.75 gains **1** mark*

2

m/s^2

1

(c) as speed increases air resistance increases

accept drag / friction for air resistance

1

reducing the resultant force

1

[7]

53 (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]

54 (a) 53 (m)

1

(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)*

2

(ii) rain on road

1

car brakes in bad condition

1

(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

2

(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

2

[9]

55 (a) (i) 0.6

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

2

newtons

accept N
*do **not** accept n*
accept Newtons

1

(ii) the same as

1

(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

1

(ii) down(wards)

accept towards the ground
accept ↓
*do **not** accept south*

1

[6]

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

or (directly) proportional

accept change by the same ratio

1

(ii) steeper straight line through the origin

judge by eye

1

(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

1

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

1

(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

2

[6]

57 (a) 4

*allow **1** mark for extracting correct information 12*

2

m/s^2

ignore negative sign

1

(b) 9 (s)

1

[4]