**M1.** (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]**

**M2.** (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]**

**M3.** (a) acceleration = $\frac{\text{change in speed/velocity}}{\text{time taken}}$

**or** $\frac{10}{4}$

*gains 1 mark*
*do not penalise if both of these present*
*but 'change in' omitted from formula*

**but**
2.5

*gains 2 marks*

unit $m/s^2$ **or** metres per second squared

**or** metres per second per second

**or** $ms^{-*}$
*for 1 mark*

3

(b) *evidence* of using area under graph or distance average speed × time
**or**

$10 \times 4 \times \frac{1}{2}$
*gains 1 mark*

**but**
20

*gains 2 marks*

*units* metres / $m^{-2*}$
*for 1 mark*

3

(c) force = mass × acceleration **or** 75 × 25

*gains 1 mark*

**but**
1875

*gains 2 marks*

**NB Correct unit to be credited even if numerical answer wrong or absent.*

2

**[8]**

**M4.** (a) *any evidence of:* momentum = mass × velocity (words, symbols or numbers)
appropriate re-arrangement mass as 0.05kg

*each gains 1 mark*

**but** 800

*gains 4 marks*

4

(b) (i) *any reference to* friction with air/air resistance

*gains 1 mark*

**but** *idea that* friction with air/air resistance is high (at high speed)

*gains 2 marks*

2

(ii) *any evidence of:* k.e. $\propto v^2$ **or** k.e. = ½ $mv^2$
final k.e.
initial k.e.
either initial or final k.e. correctly calculated (i.e. 16000; 10240)

*each gains 1 mark*

**but** $(0.8)^2$

*gains 3 marks*

**but** 64%(credit 0.64)

*gains 4 marks (also credit e.c.f)*

4

**[10]**

**M5.** (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) If inelastic ke lost
Here ke does work crumpling car
*for 1 mark each*

**2**

(iii) 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**

**[19]**

**M6.** (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]**

**M7.** (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]**

**M8.** (a) 13 500 (J)

*allow **1** mark for correct substitution, ie 90 x 10 x 15 provided no subsequent step shown*

**2**

(b) 17
**or**
$\sqrt{\frac{\text{their (a)}}{45}}$

correctly calculated and answer given to 2 or 3 significant figures

*accept 17.3*
*allow **2** marks for an answer with 4 or more significant figures, ie 17.32*
***or***
*allow **2** marks for correct substitution, ie 13 500/ their (a) = ½ x 90 x $v^2$*
***or***
*allow **1** mark for a statement or figures showing KE = GPE*

**3**

(c) work is done

**1**

(against) friction (between the miner and slide)

*accept 'air resistance' **or** 'drag' for friction*

**1**

(due to the) slide not (being perfectly) smooth

*accept miners clothing is rough*

**or**

causing (kinetic) energy to be transferred as heat/internal energy of surroundings

*accept lost/transformed for transferred*

*accept air for internal energy of surroundings*

1

**[8]**

**M9.** (a) 35 (m)

*allow **1** mark for indicating the correct area*

*allow **1** mark for obtaining correct figures from the graph*

*allow **1** mark for calculating area of triangle (25) but omitting the rectangle underneath (2 x 5)*

3

(b) 86 400

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

*ie 1/2 × 1200 × $12^2$*

2

**[5]**

**M10.** (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]**

**M11.** (a) 1.25

*allow **1** mark for correct resultant force ie 1500N*

*allow **2** marks for correct transformation and substitution*

*ie* $\frac{1500}{1200}$

*allow **1** mark for a correct transformation but clearly substituting an incorrect value for force*

*eg =* $\frac{3500}{1200}$

**3**

m/s$^2$

**1**

(b) as speed increases so does the size of the drag force

*accept frictional force / resistive force / air resistance for drag*

**1**

eventually the drag force becomes equal to the thrust

**1**

the resultant force is now equal to zero and therefore there is no further acceleration

**1**

(c) the car and van will reach top speed when the forward force equals the drag force

*accept air resistance / frictional / resistive force for drag force*

**1**

the drag force at any speed is smaller for the car than for the van

**1**

as the car is more streamlined

**1**

therefore the car's drag force will equal the forward force at a higher speed

**1**

*allow converse throughout*

**[11]**

**M12.** (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]**