M1. (a) distance is a scalar and displacement is a vector
or
distance has magnitude only, displacement has magnitude and direction

(b) 37.5 km
accept any value between 37.0 and 38.0 inclusive

062° or N62°E
accept 62° to the right of the vertical

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
acceleration is the rate of change of velocity

(d) number of squares below line = 17
accept any number between 16 and 18 inclusive

each square represents 500 m
distance = number of squares × value of each square correctly calculated − 8500 m
M2. (a) 4

*allow 1 mark for extracting correct information*

2 m/s²

*ignore negative sign*

1

(b) 9 (s)

1

[4]
M3. (a) (i) velocity includes direction
accept velocity is a vector

(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

(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

(iv) momentum before does not equal momentum after
ignore reference to energy
or total momentum changes
or an external force was applied

(b) to reduce the momentum of the driver

a smaller (constant) force would be needed
do not accept reduces the impact / impulse on the driver
M4. (a) (i) a single force that has the same effect as all the forces combined
accept all the forces added / the sum of the forces / overall force

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

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

m/s²

(c) as speed increases air resistance increases
accept drag / friction for air resistance

reducing the resultant force
M5. (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

   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 the best eg
   X – same resistance value is obtained for 2 different force values
   Y – all force values give the same resistance

   1
M6. (a) 48

allow for 1 mark correct method shown, ie $6 \times 8$
or correct area indicated on the graph

(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

horizontal line at 48m between 6 and 10 seconds

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

[4]
M7.  (a) any two from:
   • (acceleration occurs when) the direction (of each capsule) changes
   • velocity has direction
   • acceleration is (rate of) change of velocity

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

   (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

   [4]
(a) more streamlined

accept decrease surface area

air resistance is smaller (for same speed)

accept drag for air resistance
friction is insufficient

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

ignore reference to mass

(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

(ii) 7.5

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

(iii) air (resistance)

accept wind (resistance)
drag is insufficient
friction is insufficient
M9. (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

(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

(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

(b) Z

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