Mark schemes

Q1.

(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]

Q2.

(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]

Q3.
(a) 450
      *allow **1** mark for correct substitution,*
      ie 18 × 10 × 2.5 provided no subsequent step shown

2

(b) (i) friction between child ('s clothing) and slide
          accept friction between two insulators
          accept child rubs against the slide
          accept when two insulators rub (together)

1

   causes electron / charge transfer (between child and slide)
      accept specific reference, eg electrons move onto / off the child / slide
      reference to positive electrons / protons / positive charge / atoms transfer negates this mark
      answers in terms of the slide being initially charged score zero

1

(ii) all the charges (on the hair) are the same (polarity)
      accept (all) the charge/hair is negative / positive
      accept it is positive/negative

1

   charges / hairs are repelling
      both parts should be marked together

1

(iii) charge would pass through the metal (to earth)
       accept metal is a conductor
       accept metal is not an insulator
       accept there is no charge / electron transfer
       accept the slide is earthed
       accept metals contain free electrons

1

[7]

Q4.
(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]

Q5.

    (a)   (i)   <u>gravitational potential</u> (energy)

1

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

1

    (b)   (i)   slope or gradient

1

          (ii)   <u>area</u> (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]

Q6.

(a)   potential

1

(b)   (i)   13 200
   *allow **1** mark for correct substitution, ie 660 × 20 provided no
   subsequent step shown*

2

(ii)   16.5
   allow 1 mark for correct

or

$\frac{\text{their (b)(i)}}{800}$ correctly calculated

substitution, ie $\frac{13\ 200}{800}$ ***or*** $\frac{\text{their (b)(i)}}{800}$
provided no subsequent step shown

2

[5]

Q7.

(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

$\frac{their\ (b)(ii)}{8000}$ 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]

Q8.

(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]

Q9.

(a)   1800 (N)

> *allow **1** mark for correct substitution ie 180 × 10 provided no further steps shown*

2

(b)   3780
or
their (a) × 2.1 correctly calculated

> *allow **1** mark for correct substitution*
> *ie 1800 **or** their (a) × 2.1 provided no further steps shown*

2

joule

> *accept J*
> *accept any clear indication of correct answer*

1

(c)   0

> *reason does not score if 0 not chosen*

1

work is only done when a force makes an object move

> *accept distance moved is zero*
> *accept no energy transfer (to the bar)*
> *accept the bar is not moving/is stationary*
> *'it' refers to the bar/weights*

1

[7]

Q10.

(a)   (i)   24

> *allow **1** mark for converting time to 600 seconds*
> *or showing method ie 14400/10*
>
> *or* $\dfrac{14400}{10 \times 60}$
>
> *provided no further steps shown*

2

(ii)   24

> *ignore any unit*
> **or**
> their (a)(i)

1

(b)   (i)   20   45

> ***both** required – either order*

1

(ii)   the block transfers energy to the surroundings

1

[5]

Q11.

   (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]

Q12.

   (a)   (i)   horizontal arrow pointing to the left

judge by eye
drawn anywhere on the diagram

1

         (ii)   60 (N)

1

(at steady speed) resultant force must be zero

accept forces must balance/are equal
accept no acceleration
*do **not** accept constant speed*

1

   (b)   1680

*allow **1** mark for correct substitution, ie 60 x 28 provided no*
subsequent step shown

2

joule

accept J
do not accept j

1

                                                                                      [6]

Q13.

(a) (i)   720

                *allow **1** mark for correct substitution,*
                ie 72 × 10 provided no subsequent step shown
                                                                            2

     (ii) 720
           or
           their (a)(i)
                                                                            1

(b) (i)   gravitational potential
                allow gravitational
                allow potential
                                                                            1

     (ii) 432

                                          $\dfrac{21600}{50}$

                *allow **1** mark for correct substitution, ie   provided no*
                subsequent step shown
                                                                            2

           watt / W
                                                                            1

                                                                                      [7]

Q14.

(a) (i)   (connect) 30 (cells)
                                                                            1

           in series
                                                                            1

     (ii) current always flows in the same direction
           or
           current only flows one way
                                                                            1

     (iii) 36 000

                *allow **1** mark for correctly converting 2 hours to 7200*
                seconds
                *answers 10 or 600 score **1** mark*
                                                                            2

           coulombs / C
                *do **not** accept c*
                                                                            1

(b) (i)   2160

                *allow **1** mark for correct substitution, ie ½ × 120 × 6²*
                *answers of 1620 or 540 score **1** mark*

(ii) reduce it

1

any **one** from:

- draws a larger current (from battery)

- motor draws greater power (from battery)
  accept energy per second for power
  accept more energy needed to move the bicycle

- greater resistance force (to motion) / air resistance / drag / friction
  accept less streamlined
  more mass to carry is insufficient

1

[10]

Q15.

(a) 572

*allow **1** mark for correct substitution,*
ie 220 × 2.6
*allow **1** mark for*
220 × 260 = 57 200
or
220 × 2600 = 572 000
but to score this mark the entire calculation must be shown

2

(b) (i) smooth curve drawn
accept a line that is extrapolated back to 0 degrees, but not through the origin
accept a straight line of best fit (point at 40 degrees can be treated as anomalous and line may stop at 30 degrees)
*do **not** accept straight lines drawn 'dot to dot' or directly from first to last point or a line going through the origin*

1

(ii) increases
accept a positive correlation
*do **not** accept proportional*

1

(iii) long plank
no mark for this, the marks are for the explanation

makes the angle small(er) (than a short plank)
accept increases the distance
accept small(er) slope

1

a small(er) force is needed

or
short plank

no mark for this, the marks are for the explanation

a large(r) force is used over a short(er) distance (1)

less work done (1)

accept less energy transfer

1

[6]

Q16.

(a)   (i)   75 000

*accept correct substitution for **1** mark*
ie 7500 × 10

2

newtons / N

*do **not** accept n*
*full credit for using g = 9.8 **or** 9.81*

1

(ii)   60 000 000

accept for both marks
their (a)(i) × 800 correctly calculated
*accept correct substitution for **1** mark*
ie their (a)(i) × 800

2

(b)   (i)   arrow drawn parallel (to) **and** down (the) slope

accept arrow drawn anywhere on the diagram

1

(ii)   increases

1

GPE transformed to KE
or
speed increasing

accept is accelerating
however 'speed increasing' only scores if correctly linked to increasing kinetic energy

1

(c)   so more likely to wear one
or
they know wearing a helmet is likely to / will reduce (risk) head injury
or
so can make an (informed) choice (about wearing one)

1

[9]

Q17.

(a) (i) 50 (N)

ignore any units

1

(ii) resultant force

1

(iii) 4000

*accept their (a)(i) × 80 correctly calculated for **2** marks*
*allow **1** mark for correct substitution i.e. 50 × 80 or their (a)(i) × 80*
ignore any units

2

(b) (i) joule

1

(ii) heat

1

[6]

Q18.

(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]

Q19.

(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]

Q20.

(a)   concentration / tiredness / drugs / alcohol

accept any reasonable factor that could affect a driver's reactions

*do **not** accept speed or any physical condition unrelated to the driver*

1

(b)   31.25

*credit for **1** mark correct attempt to calculate the area under the slope **or** for using the equation*
distance = <u>average</u> velocity (speed) × time

*credit for **1** mark use of correct velocity change (12.5) <u>and</u> correct time (5) **or** answer of 62.5*

3

(c)   2.5

*credit for **1** mark triangle drawn on slope **or** correct equation **or** two correct pairs of coordinates*

credit for 1 mark use of correct velocity change (12.5) and correct time (5)
accept time = between 4.8 and 5.2 if used in (b)

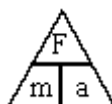*do not accept an attempt using one pair of coordinates taken from the slope*

3

metres / second / second **or** metres / second / squared **or** m/s^2 **or** ms^{-2}

1

(d)   (i)   force = mass × acceleration

accept correct transformation

accept F = m × a

accept *provided subsequent use of Δ is correct*

*do **not** accept an equation in units*

1

(ii)   2250

credit their (c) × 900 for 2 marks
*credit **1** mark for correct substitution*

2

[11]

Q21.

(a)　(i)　kinetic energy = $\frac{1}{2}$ × mass × speed²

accept ke = $\frac{1}{2}$ mv²

*do **not** accept KE = $\frac{1}{2}$ ms²*

1

(ii)　13

allow 1 mark for correct substitution or transformation

2

(b)

*if B is at the top of the curve - **no** marks*

PE at A maximum
PE at B minimum
PE at C just less than **or** = to A

*do **not** accept wavy lines **or** very non-symmetrical*
accept straight lines or curves

1

difference between A and B is 5000 to 5200

1

[5]

Q22.

(a)　(i)　work (done) = force (applied) × distance (moved)
　　　　accept W = F × s or W = F × d

accept *provided subsequent method is correct*

1

(ii)　240 000

*allow **1** mark for correct substitution **or** correct use of 1200 (N)*

2

joules
accept J
*do **not** accept j / Nm*

1

(b)　800 (watts)

accept 0.8 kW

*accept their (a)(ii) ÷ 300 correctly evaluated for **2** marks*

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

*(a)(ii) ÷ 5 correctly evaluated for **1** mark*

2

(c)　(i)　any **one** from:

　　　　•　needs to raise the chair / lift

　　　　•　lifting more than one chair

　　　　　allow lifting more than 2 people

　　　　　implication of a heavier weight

　　　　•　energy transfer to the surroundings
　　　　　correctly qualified

　　　　　accept loss for transfer

　　　　　*do **not** accept motor inefficient*

　　　　　*do **not** accept motor gets hot*

　　　　　*do **not** accept friction unless the location is specified as
　　　　　external to the motor*

1

(ii)　electrical

　　　accept electric

potential

　　　***both** answers required for the mark*

1

[8]

Q23.

(a)　(i)　gpe = weight $\times$ height

　　　　accept Ep = mgh

　　　　accept pe= mgh

1

(ii)　1200

　　　accept values using 9.8 (1)

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

2

(b)　(i)　120

　　　accept $\dfrac{their\ (a)(ii) \times 6}{60}$

1

(ii)　300

　　　allow b(i) ÷ 0.4 for both marks

　　　*allow **1** mark for correct transformation*

2

[6]

Q24.

(i)   kinetic energy = $\frac{1}{2} \times mass \times speed^2$

accept velocity for speed

accept KE = $\frac{1}{2} mv^2$

1

(ii)   32 000

accept 32 kJ

1

[2]

Q25.

(a)   (i)   gravitational potential

accept gravitational

accept potential

1

(ii)   2250 (N)

1

forces must be balanced
or
forces are equal and opposite

*do **not** accept because it is not moving*
*do **not** accept 'equilibrium' by itself*
*do **not** accept 'it is not balanced'*
*do **not** accept 'forces are equal'*
*do **not** accept 'forces are the same'*

1

(b)   1500

1 mark for correct substitution

2

[5]

Q26.

(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 $\pm$ 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 = $\dfrac{\text{change in velocity}}{\text{time taken}}$

accept correct transformation

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

accept m/s² = $\dfrac{m/s}{s}$

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

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]

Q27.

   (a)   potential; bucket/pulley

                 for 1 mark each

2

   (b)   300

                 gains 2 marks

      else working

                 gains 1 mark

2

[4]

Q28.

   (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]

Q29.

   (a)   3

                 gains 1 mark

      m/s^2

                 gains 1 mark

      else working   *gains 1 mark*

2

   (b)   2850 ecf

                 gains 1 mark

      N

                 gains 1 mark

      else working

                 gains 1 mark

(c)   friction/air resistance increases with speed;
        till frictional = max forward force;
        then force/acceleration is zero
                for 1 mark each

        alternative limitation for safety
                gains 1 mark only

3

[7]

Q30.

(a)   100
                gains 2 marks

       else working
                gains 1 mark

2

(b)   100   ecf
                for 1 mark

1

(c)   rounds to 14 (accept 14.142 or 14.14) ecf
                gains 3 marks

       else working to $v^2 = 200$
                gains 2 marks

       else initial working v = 200
                gains 1 mark

3

[6]

Q31.

(a)   20 m/s
                gets 2 marks

       Else working
                gets 1 mark

2

(b)   10 m/s

1

(c)   20 m
                gets 2 marks

        Else working
                gets 1 mark

2

(d)   12 000 N

Else working

2

(e)　2 400 000 J

Else working

2

(f)　(i)　Ans to (e)

1

　　(ii)　Ans to (e)/60
　　　　Else working

2

　　(iii)　Ans to (ii)/5

1

[13]

Q32.

(a)　$k = 1/2mv^2$
　　$k = 1/2.1.2.109.20^2$
　　$k = 2.4.10^{11}$

3

(b)　(i)　$0.6.10^9$

　　(ii)　mass halved
　　　　speed halved
　　　　$(speed)^2$ quartered
　　　　ke and/or power cut to one eight

5

[8]

Q33.

(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

4

(b)　(i)　F = ma
　　　　10 000 = 1250a
　　　　a = 8
　　　　m/s²

(ii)   ke = 1/2 mv²
        ke = 1/2 1250.48²
        ke = 1 440 000
        J
            for 1 mark each

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

[16]

Q34.

(a)   AB
            for 1 mark

1

(b)   (i)   0.7
                for 1 mark each

1

(ii)   16.8
                gains 2 marks

2

but correct working
(d = v.t, d = 24 × 0.7, or in terms of area under graph)
                gains 1 mark

1

(c)   a = (v-u)/t
        = 24/4
        = 6
        m/s²
                (see marking of calculations)

(can work in terms of graph gradient)

4

(d)   d = v.t
        = 24/2 × 4
        = 48
                (see marking of calculations)

(can work in terms of area under graph)

3

(e) F = ma
     = 800 × 6
     = 4800

> *(see marking of calculations)*

3

[15]

Q35.

(a) p = mgh
     = 50 × 10 × 4 = 2000
     J/Nm
     (see marking of calculations)

4

(b) k = ½ mv^2
     = ½ × 50 × 8^2
     = 1600
     J/Nm
     (see marking of calculations)

4

(c) work is done against air resistance
     fall of her C of G differs from rise in climbing stairs
     part of gained pe used to rotate body
     diver gains PE on take-off

> *any 2 for 1 mark each*

2

[10]