M1. (a) (i) (connect) 30 (cells) 
in series 

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

(iii) 36 000 
allow 1 mark for correctly converting 2 hours to 7200 seconds 
answers 10 or 600 score 1 mark 

coulombs / C 
do not accept c 

(b) (i) 2160 
allow 1 mark for correct substitution, ie \( \frac{1}{2} \times 120 \times 6 \) 
answers of 1620 or 540 score 1 mark 

(ii) reduce it 

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
M2.  (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
M3. (a) (i) 100 (m)

(ii) stationary

(iii) accelerating

(iv) tangent drawn at t = 45 s

attempt to determine slope

speed in the range 3.2 – 4.2 (m / s)
dependent on 1st marking point

(b) (i) 500 000 (J)

ignore negative sign

(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

(iii) (kinetic) energy transferred by heating
to the brakes

ignore references to sound energy

if no other marks scored allow k.e. decreases for 1 mark
M4. (a) 47250
answers of 1350/ 33750/ 48600 gain 1 mark
allow 1 mark for correct substitution using both 18 and 3

(b) (i) 47250 or their (a)
accept statement ‘same as the KE (lost)’
ignore any units

(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
M5. (a) 98
allow 1 mark for correct substitution
ie $\frac{1}{2} \times 0.16 \times 35 \times 35$ provided no subsequent step shown
an answer of 98 000 scores 0

(b) (i) 9.6
allow 1 mark for (change in velocity =) 60
ignore negative sign

(ii) 9600
ignore negative sign
or their (b)(i) ÷ 0.001 correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

to reduce/change momentum (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
M6. (a) (i) distance vehicle travels during driver’s reaction time
accept distance vehicle travels while driver reacts

(ii) any two from:
- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age
accept as an alternative factor distractions, eg using a mobile phone

(b) (i) 320 000
allow 1 mark for correct substitution, ie \( \frac{1}{2} \times 1600 \times 20^2 \)
provided no subsequent step shown

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

(iii) 40

or

their (b)(ii) 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)

(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

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

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

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

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