

Mark schemes

1	(a) D	1
	(b) C	1
	(c) $W = 300 \times 45$	1
	$W = 13\,500$	1
	<i>allow 13 500 with no working shown for 2 marks</i>	
(d) straight line drawn from 13 m / s to 0 m / s		1
	finishing on x-axis at 65 s	1
		[6]
2	(a) (i) 100 (m)	1
	(ii) stationary	1
	(iii) accelerating	1
	(iv) tangent drawn at $t = 45$ s	1
	<i>attempt to determine slope</i>	1
	speed in the range 3.2 – 4.2 (m / s)	
	<i>dependent on 1st marking point</i>	1
	(b) (i) 500 000 (J)	
	<i>ignore negative sign</i>	1
	(ii) 20 000 (N)	
<i>ignore negative sign</i>		
<i>allow 1 mark for correct substitution, ie</i>		
<i>$500\,000 = F \times 25$</i>		
<i>or their part (b)(i) = $F \times 25$</i>		
<i>provided no subsequent step</i>	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]

3

(a) 450

allow 1 mark for correct substitution,

ie $18 \times 10 \times 2.5$ 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]

4

(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

(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]

5 (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 $80 \neq 65$

1

student 2 correct because average velocities similar

ecf from (c)(i)

1

student 3 incorrect because times are different

1

[12]

- 6** (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

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

substitution, ie $\frac{13\,200}{800}$ or $\frac{\text{their (b)(i)}}{800}$

provided no subsequent step shown

2

[5]

- 7** (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

their (b)(ii) correctly calculated
8000

allow 1 mark for statement work done = KE lost

or

*allow 1 mark for correct substitution, ie
 $8000 \times \text{distance} = 320\,000$ **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]

8

(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]

9

(a) 1800 (N)

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

2

(b) 3780

or

their (a) \times 2.1 correctly calculated

allow 1 mark for correct substitution

*ie 1800 **or** their (a) \times 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]

10

(a) (i) 24

allow 1 mark for converting time to 600 seconds
or showing method ie 14400/10

or $\frac{14400}{10 \times 60}$

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]

11

(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

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) $\div 0.001$ correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

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

[7]

12

(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]

13

(a) (i) 720

allow 1 mark for correct substitution,

ie 72 x 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

allow 1 mark for correct substitution, ie $\frac{21600}{50}$ provided no subsequent step shown

2

watt / W

1

[7]

14

(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 $\frac{1}{2} \times 120 \times 6^2$
answers of 1620 or 540 score 1 mark

2

(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]

15

(a) 572

allow 1 mark for correct substitution,

ie 220×2.6

allow 1 mark for

$220 \times 260 = 57\,200$

or

$220 \times 2600 = 572\,000$

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]

16

(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) $\times 800$ correctly calculated

accept correct substitution for 1 mark

ie their (a)(i) $\times 800$

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]

17

(a) (i) 50 (N)

ignore any units

1

(ii) resultant force

1

(iii) 4000

accept their (a)(i) $\times 80$ correctly calculated for 2 marks

allow 1 mark for correct substitution i.e. 50×80 or their (a)(i) $\times 80$

ignore any units

2

- (b) (i) joule 1
- (ii) heat 1

[6]

18

- (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]

19

- (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/s² 1

- (c) as speed increases air resistance increases
accept drag / friction for air resistance 1

reducing the resultant force 1

[7]

20

- (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 = average velocity (speed) × time
credit for 1 mark use of correct velocity change (12.5) and 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

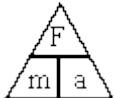
3

metres / second / second **or** metres / second / squared **or** m/s² **or** ms⁻²

1

- (d) (i) force = mass × acceleration

accept correct transformation
accept $F = m \times a$

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]

21

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

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

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

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]

22

(a) (i) work (done) = force (applied) x distance (moved)

accept $W = F \times s$ or $W = F \times d$

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]

23

- (a) (i) $\text{gpe} = \text{weight} \times \text{height}$
*accept $E_p = mgh$
accept $pe = mgh$*
- 1
- (ii) 1200
*accept values using 9.8 (1)
allow 1 mark for correct substitution*
- 2
- (b) (i) 120
accept $\frac{\text{their (a)(ii)} \times 6}{60}$
- 1
- (ii) 300
*allow $b(i) \div 0.4$ for both marks
allow 1 mark for correct transformation*
- 2

[6]

24

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

accept velocity for speed

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

1

(ii) 32 000

accept 32 kJ

1

[2]

25

(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]

26

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

accept correct transformation

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

accept $m/s^2 = \frac{m/s}{s}$

do not accept acceleration = $\frac{\text{velocity}}{\text{time}}$

1

(ii) 56
accept -56

1

(iii) deceleration is reduced
accept deceleration is slower
accept acceleration 1

force on car and or passengers is reduced
accept an answer in terms of change in momentum for full credit 1

[11]

27

(a) potential; bucket/pulley
for 1 mark each 2

(b) 300
gains 2 marks
else working
gains 1 mark 2

[4]

28

(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]

29

(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

2

(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]

30

(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]

31

(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
gets 2 marks

Else working
gets 1 mark

2

(e) 2 400 000 J
gets 2 marks

Else working
gets 1 mark

2

(f) (i) Ans to (e)

1

(ii) Ans to (e)/60
Else working

2

(iii) Ans to (ii)/5

1

[13]

32

(a) $k = 1/2mv^2$
 $k = 1/2.1.2.109.202$
 $k = 2.4.1011$
for one mark each

3

- (b) (i) 0.6.109
- (ii) mass halved
 speed halved
 (speed)² quartered
 ke and/or power cut to one eight
for 1 mark each

5

[8]

33

- (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) $ke = \frac{1}{2} mv^2$
 $ke = \frac{1}{2} 1250.48^2$
 $ke = 1\,440\,000$
 J
for 1 mark each

4

- (iii) $W = Fd$
 $W = 10\,000.144$
 $W = 1\,440\,000$
 J
for 1 mark each

4

[16]

34

- (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

($d = v.t$, $d = 24 \times 0.7$, or in terms of area under graph)

gains 1 mark

1

(c) $a = (v-u)/t$
 $= 24/4$
 $= 6$
 m/s^2

(see marking of calculations)

(can work in terms of graph gradient)

4

(d) $d = v.t$
 $= 24/2 \times 4$
 $= 48$

(see marking of calculations)

(can work in terms of area under graph)

3

(e) $F = ma$
 $= 800 \times 6$
 $= 4800$

(see marking of calculations)

3

[15]

35

(a) $p = mgh$
 $= 50 \times 10 \times 4 = 2000$
 J/Nm

(see marking of calculations)

4

(b) $k = \frac{1}{2} mv^2$
 $= \frac{1}{2} \times 50 \times 8^2$
 $= 1600$
 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]

36	(i) 700 or 686 <i>gets 2</i>	
	Else mg or 70×10 or 70×9.8 (1) <i>gets 1</i>	2
	(ii) 350J <i>gets 4</i>	
	Else 350 <i>gets 3</i>	
	Else 700×0.5 <i>gets 2</i>	
	Else $W = F.d.$ <i>gets 1</i>	
	Any answer with unit J may score 1, 2 or 3 (see general instructions)	4
		[6]
37	(a) product of mass and velocity	1
	(b) (i) 4kg or 4000g	1
	(ii) $M = 8\text{kgm/s}$ or Ns <i>for 3 marks</i>	
	else $M = 8$ <i>for 2 marks</i>	
	else $M - mv$ or 4×2 <i>for 1 mark</i>	3
	(iii) 8 kgm/s (watch e.c.f.)	1
	(iv) $v = 400$ <i>for 3 marks</i>	
	else $v = 8/0.02$ <i>for 2 marks</i>	
	else $M - mv$, $v - M/m$ or $8 = 0.02v$ <i>for 1 mark</i>	3

(v) $ke = 8$

for 3 marks

else $ke = 1/2 (4 \times 2^2)$

for 2 marks

else $ke = 1/2 (mv^2)$

for 1 mark

3

(vi) transferred to heat and sound

or does work against wood/pushing wood aside/deforming bullet

1

[13]

38

(a) $W = 65 \times 10$

(allow a maximum of 3 marks if candidate uses $g = 9.8N / Kg$ (as ecf))

gains 1 mark

but

$W = 650 (N)$

(allow use of p.e. = $m \times g \times h$)

gains 2 marks

but

PE change = 650×1.25 or $65 \times 10 \times 1.25$

gains 3 marks

but

PE change = $812.5 (J)$ (allow 813J or 812J)

gains 4 marks

4

(b) k.e. = p.e.

gains 1 mark

but

$(\text{speed})^2 = 812.5 \times 2 / 65$ or $812.5 = \frac{1}{2} \times 65 \times (\text{speed})^2$ ecf

gains 2 marks

but

speed = $5 (m/s)$ (allow $4.99 \rightarrow 5.002$)

(if answer = 25m/s check working: $812.5 = \frac{1}{2} m \times v^2$ gains 1 mark for KE = PE)

(but if $812.5 = \frac{1}{2} m \times v^2 = \frac{1}{2} \times 65 \times v^2$ or $v^2 = \frac{2 \times 812.5}{65}$ gains 2 marks)

25, with no working shown gains 0 marks

gains 3 marks

3

[7]

39

(a) mass 1

(b) work (done) = force (applied) × distance (moved in the direction of the force)
do not accept correctly substituted figures for this equation mark
accept $W = Fs$ or $W = Fd$ or $W = Fh$ (well done) = force × height
mark formula independently 1

$$1\ 000\ 000 \times 15$$

allow $1\ 000\ 000 \times \frac{15}{1000}$

1

$$= 15\ 000\ 000$$

$= 15\ 000$

1

J / joules

KJ / kilojoules

1

allow $1\ 000\ 000 \times 1500$

= 15 00 000 000 for 1 mark

only – no unit mark

allow 3 marks for correct answer if no working / correct working is shown

(c) **Quality of written communication**

The answer to this question requires ideas in good English, in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme

Max.4 if ideas not well expressed

A – B not moving

accept stationary or at rest

1

B - C acceleration or **C – D**

acceleration

accept increases speed / velocity accept gets faster

1

comparison made that the acceleration

B – C is less than **C – D**

*accept comparison made that the acceleration **C-D** is greater than **B-C***

1

D – E constant velocity

accept steady speed or at 0.4 m/s

1

E – F deceleration

accept decreases speed / velocity

accept gets slower

1

[10]

40

(a) the greater the mass / weight

1

then the greater the kinetic energy

accept the greater the momentum

accept greater mass / weight therefore greater force = 2

1

(b) (i)

Note: this calculation requires candidates to show clearly how they work out their answer

$$\text{k.e. } \frac{1}{2} mv^2$$

accept evidence of equation

1

86 400 (J) at 12 m/s

accept $\frac{1}{2} \times 1200 \times 12^2$ or 86.4 KJ

1

194 400 (J) at 18 m/s

accept $\frac{1}{2} \times 1200 \times 18^2$ or 194.4KJ

1

increase in k.e. = 108 000

NB 10800 = 0 marks

N.B. if no working at all then max 3 for a correct numerical answer

1

joules **or J**

accept 108 kilojoules or kJ

1

(ii) explanation that $ke \propto v^2$

1

[8]

- 41** newton **or** N
metre **or** m
joules **or** J

*all three correct 2 marks
two or one correct 1 mark*

[2]

- 42** 8550

*correct answer with no working = 3
if incorrect, allow 1 mark for work = force / weight \times distance, 2
marks for = 1900×4.5
N.B. correct answer from the incorrectly recalled relationship mass
 \times distance = 2 marks*

[3]

- 43** 12 100

*correct answer with no working = 3
if answer incorrect, allow 1 mark for force = mass \times acceleration
 $1210 \times 10 = 2$ force / weight = mass \times gravity is neutral
N.B. no marks for correct answers with incorrectly recalled
relationship*

[3]

- 44** 900 000

correct with no working = 3 if answer incorrect, allow:

1 mark for K.E. = $\frac{1}{2} \times \text{mass} \times \text{speed}^2$

2 marks for $\frac{1}{2} \times 5000 \times 600^2$

N.B. correct answer with the incorrectly recalled relationship

$\frac{1}{2} \times \text{weight} \times \text{speed}^2 = 2$ marks

[3]

- 45** 1050

kg

if answer incorrect then kinetic energy = $\frac{1}{2} mv^2$ or

accept indication by correct substitution for 1 mark

accept 900 for 1 mark

accept $m = \frac{2KE}{v^2}$ or indication by correct substitution for 1 mark

4

1

[5]

46

(a) **either**
gravity

1

due to mass of the Earth

or

(the) interaction / attraction between the (1)

mass of the block
and the mass of the Earth (1)

1

(b) (i) 4.5 N

unit required accept equal to weight (lifted)

do not credit ..mass..

1

(ii) the forces are balanced

accept because the block is not accelerating

accept because the block is moving at a steady speed (in a straight line) accept because the block's velocity is

constant

1

(c) (i) **either**
4.05 J

3

or

work (done)

= force (applied)

× distance (moved in the
direction of the force)

or *work = 4.5 × 0.9*

note '= 4.5 × 0.9' is not an equation

1

= 4.05

1

joules **or** J **or** newton metres

405 J will be a common answer

it gets (1) (for the unit) if correct equation is not shown but (2)

otherwise

4.5 ÷ 0.9, or variations on this theme, get (1) (for the unit) at most

1

(ii) 4.05 J

or *same as the answer to (c) (i) provided that the same unit for energy is shown in both cases*

1

(d) 4.16

accept 4, 4.2, 4.17, 4.16

1

[10]

47

(a) (i) work = force \times distance

or any correctly transposed version e.g.

$$\text{force} = \frac{\text{work}}{\text{distance}}$$

or in correct units throughout e.g.

$$J = N \times m$$

or in acceptable abbreviations e.g.

$$W = f \times d$$

do not credit $W = Nm$ or any other

ambiguous or unclear response

do not credit



unless subsequent calculation shows understanding

1

(ii) **EITHER**

3.7 (m)

2

OR

$$(\text{distance} =) \frac{2000}{540}$$

1

(iii) 2000 J

unit required

1

(b) **EITHER**

20

3

OR

$$\text{speed}^2 = 600 \div 1.5$$

$$\text{or speed}^2 = 600 \times \frac{2}{3}$$

$$\text{or speed}^2 = 400$$

$$\text{or speed}^2 = KE \div \frac{1}{2} \text{ mass}$$

1

metres per second

or m/s

1

(c) any **three** from

deceleration (would be) (very) great

or rate of change of speed / velocity would be (very) great

(because) $F = ma$

or (because) force is proportional to deceleration / (negative) acceleration

(so the) force (on Susan / the rope) would be (very) great

do not credit she would be hurt

do not credit just the rope could snap

the rope may exceed its elastic limit

3

[10]

48

(centre of the) Earth [not ground]

gravity

newtons (allow N)

each for 1 mark

[3]

49

(a) $WD = \text{force} \times \text{distance}$ **or** 6×2

gains 1 mark

but 12 *gains 2 marks*

units J/joules [credit Nn]

for 1 mark

3

(b) 0.6 (i.e. using the **recalled** 10N/kg)

gains 1 mark

but evidence of force = mass × acceleration

or of correct substitution e.g. 6/9.8

gains 2 marks

but 0.61 (2...)

gains 3 marks

3

(c) *any reference to*
initial acceleration due to gravity
(force due to) friction/air resistance

each for 1 mark

ideas that

this increases as speed increases

forces eventually balance

each for 1 further mark

9

[9]

50

(a) *evidence of acceleration = $\frac{\text{change in speed}}{\text{time}}$ or $\frac{0.6}{3}$

gains 1 mark

but 0.2

gains 2 marks

units m/s²

for 1 mark

3

(b) (i) 2000 **or** 1960

for 1 mark

1

(ii) evidence of power = $\frac{\text{work done}}{\text{time taken}}$ **or** weight × speed (*credit figures*) / $\frac{25}{0.6}$

(iii) $\frac{25}{0.6}$

gains 1 mark

but 1200/1176 **or** figure consistent with (b)(i)

gains 2 marks

2

(c) *evidence of force = mass × acceleration* **or** 200×0.3
gains 1 mark

but 60

gains 2 marks

but 60 + weight of girder (2060/2020*) *(or figure consistent with (b)(i))*

gains 3 marks

3

[9]

51

(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. = $\frac{1}{2} mv^2$*

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]

52

(a) D

for 1 mark

1

(b) wear it away **or** make it warmer

for 1 mark do not accept 'stops it'

1

[2]

53

(a) evidence of $\frac{\text{change in speed}}{\text{time taken}}$ or $\frac{3}{12}$

gains 1 mark

but 0.25 or $\frac{1}{4}$

gains 2 marks

2

(b) evidence of $\frac{\text{work done}}{\text{time taken}}$ or $\frac{2400}{12}$

gains 1 mark

but 200

gains 2 marks

2

(c) *idea that*

second car has a bigger mass
(allow bigger weight/heavier)

gains 1 mark

but

second car has 1.5 times bigger mass

or

second car has mass of 1200 kg

gains 2 marks

2

(d) friction/resistance increases with speed

gains 1 marks

but

friction with/resistance of air increases with speed

gains 2 marks

- increase in speed because driving force greater than friction
- steady speed when friction = driving force

or

increases in speed until friction = driving force

each for 1 further mark to maximum of 3

3

[9]

54

(a) work done = force x distance **or** 250×5 **NB** if formula given must be correct

gains 1 mark

but

1250

gains 2 marks

[In this and similar examples, a correct answer only gets full marks.

From an incorrect formula, do not allow marks for 'error carried forward'

2

- (b) • (mainly) (transferred as) it is kinetic / movement energy (not 'mechanical')
 - (some) lost / wasted / transferred as heat / sound
- [Answers must refer to 'energy'. Do not allow 'it drives the bike']*

or

used to overcome friction / air resistance

each for 1 mark

2

[4]

55

(a) [NB e.c.f not allowed from incorrect formula]

work done = force x distance or 250×5

gains 1 mark

but

1250

gains 2 marks

2

- (b) • (mainly) transferred as kinetic / movement energy
[not makes bike move]
 - (some) lost / wasted / transferred as heat / sound
- or**
used to overcome friction / air resistance
- each for 1 mark*

2

[4]

56

(a) force distance (*either way round*)
energy
for 1 mark each

3

(b) joules

for 1 mark

1

[4]