A-Level Physics

Work, Energy and Power

Mark Scheme

Time available: 66 minutes
Marks available: 53 marks

Mark schemes

1. (a) Tangent drawn at t = 2.0±1 s ✓

Use of suvat loses first 2 marks

Guidance- take tangent point to be half-way between where the line clearly leaves the curve

1

Mean deceleration from use of tangent using correct coordinates (correct Δv and Δt) and answer in range (-)2.5 to (-)2.9 (m s^{-2}) ✓

Ignore minus sign

=15/5.5 = 2.7(3) m s^{-2}

Allow if answer rounds to these values

1

Use of F = ma using their a with answer

i.e. Force =1.8 × 10^4 × their a from an attempt at a tangent or trying to use *suvat* equation✓

Answers from best attempts at tangent in range 4.7 to 4.9 × 10^4 N

1

(b) Attempt to estimate area under the graph ✓

Use of suvat equation = 0

1

Correct square count 21 to 23 10 mm squares

(525-575 small squares)

OR

distance per square = 2.5 m or 0.1 m✓

For attempt to find area using trapezium rule expect use of 1 s intervals for this mark

1

Value in range 50 m to 60 m **and conclusion**

that escape lane would be long enough✓

1

(c) KE of lorry :

to KE of gravel (as it is pushed aside/moved)✓

OR

PE of gravel (as it may be ejected upwards)✓

Ignore losses due to friction

Not KE of the ground

1

transfer to thermal energy /internal energy/heating of gravel /ground/lorry

OR

work done on the gravel/vehicle increasing internal energy/raising temperature✓

Must refer to what is heated

1

Max 2

(d) Appreciates that KE converted into PE

OR

May be stated or by attempt to use of $mgh = ½ mv^2$

OR

Calculates initial KE of lorry $½1.8 \times 10^4 \times 17.5^2 = 2.76 \times 10^6$ (J) ✓

1

Height needed in escape lane = $2.76 \times 10^6/(1.8 \times 10^4 \times 9.81) = 15.6$ m

OR

Length of lane required = 15.6/sin25 = 37 m (compare with 85 m)

OR

vertical height of ramp = 35.9 m (compare with height needed 15.6 m)

OR

maximum change in PE possible = $85 \sin 25 \times 9.81 \times 1.8 \times 10^4 = 6.3 \times 10^6$ (J)

(compare with initial KE) ✓

Allow max 2 if height = 85 tan 25

or length of lane = 15.6/tan 25

i.e. allow these incorrect values when drawing conclusion

1

Comparison and conclusion that escape lane would be long enough. This must follow from correct working✓

....

Deceleration produced by slope = 9.8(1) sin 25 or

4.15 (4.1 or 4.2) m s^{-2} seen✓

Distance to stop from $v^2 = 2as$ give s = 37 m (compare with 85 m)✓

Arriving at 37 m gets first two marks

OR

Minimum deceleration needed = $17.5^2/2 \times 85$ = 1.8 m s^{-2} (compare with 4.15 m s^{-2})

Comparison and conclusion that escape lane would be long enough This must follow from correct working✓

1

(e) The straight road of uniform gradient because:

The deceleration (condone acceleration) is uniform ✓

with the gravel the initial deceleration is larger/may vary ✓

Travelling through gravel could make the vehicle unstable/bounce erratically(owtte) ✓

Gravel because:

On the ramp the lorry would roll backwards after stopping (as it has no brakes)

Do not allow deceleration less when on gravel(It is greater initially)

Do not allow answers that (average) force using gravel lane is less than decelerating force on the ramp (due to increased stopping distance or stopping time)

Or because stopping time is longer

MAX 1

[12]

2. (a) E_k E_p or $v = \sqrt{2gh}$ ✓

$= \sqrt{2 \times 9.81 \times 90}$

= 42.0 (m s^{-1}) ✓

First mark for realising energy transformation from GPE to KE.

Second mark for correct answer.

2

(b) calculation of area of pipe (=0.0833 m^2) ✓

radius = $\sqrt{\frac{0.0833}{\pi}}$ = 0.16 (m) ✓

2

(c) mass of water / s = 3500 kg ✓

energy available per second = 0.5 × 3500 × ($42^2 - 12^2$) ✓

= 2.8 ✓ MW ✓

4

(d) heat / mechanical friction in turbines ✓

friction at walls of pipes / turbulence ✓

electrical heating in wires ✓

*Do **not** allow (friction) bald.*

Seat of loss must be clear.

Max 2

[10]

3. (a) Max GPE of block = Mgh = 0.46 × 9.81 × 0.63 = 2.84 J ✓

The first mark is for working out the GPE of the block

1

Initial KE of block = ½ Mv^2 = 2.84 J

Initial speed of block v^2 = (2 × 2.84) / 0.46

v = 3.51 ms^{-1} ✓

The second mark is for working out the speed of the block initially

1

momentum lost by pellet = momentum gained by block

= Mv = 0.46 × 3.51 = 1.61 kg m s^{-1} ✓

The third mark is for working out the momentum of the block (and therefore pellet)

1

Speed of pellet = 1.58 / m = 1.58 / 8.8 × 10^{-3} = 180 ms^{-1} (183) ✓

The final mark is for the speed of the pellet

1

At each step the mark is for the method rather than the calculated answer

Allow one consequential error in the final answer

(b) As pellet rebounds, change in momentum of pellet greater and therefore the change in momentum of the block is greater ✓

Ignore any discussion of air resistance

1

Initial speed of block is greater ✓

1

(Mass stays the same)

Initial KE of block greater ✓

1

Therefore height reached by steel block is greater than with wooden block ✓

1

(c) Calculation of steel method will need to assume that collision is elastic so that change of momentum can be calculated ✓

1

This is unlikely due to deformation of bullet, production of sound etc. ✓

1

And therefore steel method unlikely to produce accurate results.

[10]

4. (a) (i) *(a =(v-u) / t)*

= 27.8 (−0) / 4.6 = 6.04 ✓

= 6.0 (ms^{-1}) ✓

no need to see working for the mark

2 sig fig mark stands alone

2

(ii) (*F = ma*)

= (360 + 82) × 6.0(4) ✓ (allow CE from (i))

= 2700 (N) ✓ (2670 N or 2652 N)

F = 442 × (i)

1 mark may be gained if mass of rider is ignored giving answer 2200N from 2175N

2

(b) (forward force would have to) increase ✓

air resistance / drag increases (with speed) ✓

driving / forward force must be greater than resistive / drag force ✓

no mark for wind resistance

(so that) resultant / net force stayed the same / otherwise the resultant / net force would decrease ✓

4max3

(c) horizontal force arrows on both wheels towards the right starting where tyre meets road or on the axle labelled driving force or equivalent ✓

ignore the actual lengths of any arrows

ignore any arrows simply labelled 'friction'

a horizontal arrow to the left starting anywhere on the vehicle labelled drag / air resistance

no mark for wind resistance, resistance or friction force

the base of an arrow is where the force is applied

2

(d) ($F = P / v$)

= 22 000 / 55 ✓ Condone 22 / 55 for this mark

= 400 ✓ (N)

2

[11]

5. (a) (i) use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s / g$ ✓

$t = \sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50

Some working required for full marks. Correct answer only gets 2

3

(ii) ($s = vt$)

= 8.5 × 0.4946 ✓ ecf ai

= 4.2 m ✓ (4.20) ecf from ai

2

(b) (i) $\left(s = \frac{1}{2}(u + v)\,t\right)$

$t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓

$= \frac{2 \times 0.35}{8.5}$ = 8.2 × 10^{-2} (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1

Allow alternative correct approaches

2

(ii) $a = (v - u) / t$ OR correct substitution OR a = 103 ✓
(= −8.5) / 8.24 × 10^{-2} = 103.2)

(*F* = *ma* =) 75 × (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question.

= 7700 N ✓ (7741) ecf (see above)

Or from loss of KE

Some working required for full marks. Correct answer only gets 2

3

[10]