# A-Level Physics

## Motion Along a Straight Line

### Mark Scheme

**Time available: 65 minutes**
**Marks available: 47 marks**

**1.** (a) (component of total weight parallel to slope =) 640 sin $\theta$ ✓

*Allow mg sin $\theta$ or 65g sin $\theta$*

**1**

(b) use of $P = Fv$ ✓

($\theta$ =) 17 (°) ✓

*Ecf from **(a)***

*Alternative MP1:*

*Determines work done in one second*

*310 = mgh giving h = 0.486*

*and*

*determines the distance travelled along the slope of the hill = 1.63*

***OR***

*Use of*

$\sin\theta = \frac{\text{height gained per second}}{\text{distance travelled per second}}$

**2**

(c) Gains less height every second ✓

Gains less potential energy every second ✓

Less useful power output ✓

*Alternatives:*

*Force applied acts over a greater distance for the same change in height* ✓

*Less force required* ✓

*Less power output required* ✓

***OR***

*Same gain in GPE requires same gain in height* ✓

*Takes longer time to gain height as greater distance to travel* ✓

*Less power output* ✓

***OR***

*Effective* $\theta$ *has decreased* ✓

*mg sin* $\theta$ *has decreased* ✓

*less power output* ✓

***OR***

*The component of the velocity parallel to the slope has decreased* ✓

$P = Fv \cos \theta$ *has decreased* ✓

*Less power output* ✓

*General marking principle:*

*MP1 basic point / MP2 consequence (in terms of energy) / MP3 less power*

**3**

(d) Draws tangent to curve at $t$ = 10 s ✓

Attempts to determine gradient of tangent ✓

(acceleration =) 0.21 (m $s^{-2}$) ✓

*Accept answers in range 0.16 to 0.26 (m* $s^{-2}$*)*

**3**

(e) Air resistance increases with speed ✓

And

**MAX 3** from:

Initially, all energy transferred (per sec) to kinetic energy of cyclist ✓

As speed increases energy transferred (per second) to kinetic energy of cyclist decreases ✓

As speed increases energy transferred (per second) to the air increases ✓

At top speed energy transferred (per second) is transferred to air ✓

**4**

**[13]**

**2.** (a) ($a$ =) 9.81 sin30 = 4.9 (m s$^{-2}$) seen ✓

*Allow g sin30*

**1**

(b) Substitutes into $v^2 = u^2 + 2as$ eg $v^2 = 2 \times 5 \times 0.3$

**OR**

Uses $\frac{v^2}{2} = g\ 0.3 \cos 60$ ✓

1.7 (m s$^{-1}$) ✓

**2**

(c) Attempt to find area between 0.35 s (**B**) and 0.80 s (**C**) ✓

395 ± 25 (N s) ✓

**2**

(d) Reads duration from **C** to **D** from graph: 0.61 or 0.62 (s) ✓

Uses $s = \frac{1}{2}\ at^2$ OR $s = \frac{1}{2}(u + v)t$ ✓

0.46 or 0.47 (m) ✓

*Condone 9.81 for a.*

*Expect to see u = 1.52 (m s$^{-1}$) in* $s = \frac{1}{2}(u + v)t$

**3**

(e) Reads resting force from graph = 360 N **OR** divides an incorrect reading by 5 (4.91 N/kg) ✓

72 (kg) ✓

**2**

**[10]**

**3.** (a) (Work done = lost KE = ½ $mv^2$ =) 0.019 (J) ✓

**1**

(b) Use of $W = Fs$ ✓

($F$ =) 0.66 ($N$) ✓

*Condone POT error in substitution*

*ECF from* ***(a)***

***Alternative:***

*Use of an appropriate suvat equation* ***and*** *use of* $F = ma$ ✓

*($t = 9.8 \times 10^{-6}$ s)*

*($a = 6.0 \times 10^{8}$ m $s^{-2}$)*

*Condone POT error in substitution*

*No ECF from 3.1 this route ($F$ =) 0.66 ($N$)* ✓

**2**

(c) Use of Volume = Thickness x area of cross-section✓

*Condone POT errors apart from final answer ($V$ =) 8 × $10^{-4}$ × 0.03*
*Or ($V$ =) 2.4 × $10^{-5}$*

(Average density =) $\frac{50+5}{2} = 27.5$ ✓

Use of density = $\frac{\text{mass}}{\text{volume}}$ ✓

*Condone use of their density and volume*

(mass =) 6.6 × $10^{-4}$ (kg) ✓ c.a.o

**Alternative:**

Use of Volume = Thickness x area of cross-section✓

*Condone POT errors apart from final answer*

*($V$ =) 8 x $10^{-4}$ × 0.03 Or ($V$ =) 2.4 × $10^{-5}$*

Use of density = $\frac{\text{mass}}{\text{volume}}$ / (mass =) 1.2 x $10^{-3}$ or 1.2 x $10^{-4}$✓

(Average mass =) $\frac{1.2\times10^{-3}+1.2\times10^{-4}}{2}$ ✓

= 6.6 × 10– 4 (kg) ✓ c.a.o

*Condone use of their density and volume (50 kg $m^{-3}$ =1.2 x $10^{-3}$)*

*(5 kg $m^{-3}$ =1.2 x $10^{-4}$)*

**Alternative:**

Condone POT errors apart from final answer

Attempts to determine the area under the graph:

Formula for area of a rectangle added to the formula for area of a triangle seen / formula for the area of trapezium seen✓

$5 \times 0.03 + \frac{(50-5)\times0.03}{2} = 0.825\ (kg\ m^{-2})$
***or*** $\frac{50+5}{2} \times 0.03 = 0.825\ (kg\ m^{-2})$ ✓

Multiplies their area by 8 x $10^{-4}$✓

Mass = 6.6 × $10^{-4}$ (kg) ✓ c.a.o

**4**

(d) **Q** has a larger volume (for the same mass and KE) /

**Q** has a larger surface area (for the same mass and KE) ✓

**Q** will experience a greater resistive force (at any given speed) / **Q** will displace more matter per unit distance✓

**Q** will do more work per unit distance / **Q** will transfer more of its kinetic energy per unit distance / **Q** will experience a greater deceleration✓

*Must have **Q** will travel a shorter distance for all 3 marks.*

**3**

**[10]**

**4.**

(a) Evidence of distance travelled = area under graph = 1755 + 1440 + 1620 = 4815 ✓

*Full marks can be credited for use of suvat.*

Average speed = total distance/time taken = 4815/240

= 20.1 m $s^{-1}$ ✓ (at least 3sf)

Which is less than (speed) limit, (and therefore the answer is No). ✓

*Allow ecf for distance in MP2*

*Only award MP3 for incorrect speed if attempt made to calculate distance correctly e.g. area under graph OR a.e. in distance or speed*

Alternative for MP2 and MP3

Calculation of distance travelled at speed limit = 5280 m ✓

Which is greater than distance travelled (so no). ✓

*Alternative for MP1 and MP2:*

*Total area = 80.25 m $s^{-1}$ min* ✓

*Time = 4 min*

*Average = 20.1 m $s^{-1}$* ✓

**3**

(b) Using reaction time of 2.0 s ✓

**1**

Use of distance = speed × time = 62 m.

62 m (would be appropriate). ✓

*Award MP2 if 1.6 s (to give 50 m) or 1.8 s (to give 56 m) or 1.7 s (to give 53 m) or average of two distances used*

*Allow 60 m.*

**1**

(c) Use of F = ma to calculate acceleration.

$a$ = 6800/1200 ✓ = 5.7 m $s^{-2}$

evidence of use of suvat to calculate s or t, ✓

to give $t$ = 5.5 s ✓

$s$ = 85 m. ✓

*If no other mark given, allow 1 mark for*

*mv = 1200 × 31 (= 37200)*

*Alternative for MP1 and MP2*

$t = \frac{mv-mu}{F}$

*Allow ce for a.*

*Allow ce for either incorrect s or t.*

**4**

(d) (It is assumed that) the car in front would take the same time/travel the same distance as the car behind when braking/ only difference is reaction time of the driver of car behind. ✓
Or
Car in front cannot stop instantaneously (so car behind will have time/distance to bring car to rest).or words to that effect

*Alternative:*
*suggestion that total stopping distance is too large (drivers would ignore it/inefficient use of motorway)*

**1**

(e) Correct use of cos (5) ✓

E.g.

$mg = N \cos(5)$

Correct use of sin (5) ✓

E.g.

$N \sin(5)$ (= $mv^2/r$)

So

$mv^2/r$ seen ✓

And $v = (rg \tan(5))^{\frac{1}{2}}$

Gives $v = (200 \times 9.81 \times \tan(5))^{\frac{1}{2}} = 13$

So speed limit = 13 m $s^{-1}$ ✓

*May see cos (85) for sin (5)*

*Alternative for MP1 and MP2: Evidence of mg tan (5)*

*fourth mark is for answer and suggesting this as the speed limit.*

*Max 3 if mg = N used*

**4**

**[14]**