Access Tuition

A-Level Physics

Newtons Laws of Motion

Mark Scheme

Time available: 65 minutes
Marks available: 49 marks

1. (a) Use of $p = mv$ **or** estimates walking speed = 1 or 2 m/s✓

Allow use of where m has been made the subject and p has been substituted.

Accept any answer in range 2×10^6 to 10×10^6 (kg) ✓

Range on answer:

(Using speeds in range 0.5 ms^{-1} to 2.5 ms^{-1})

Accept 1 significant figure answer

2

(b) **Max 4**

There is a force on the water (from the propeller) and this produces an equal force on the propeller (from the water in the opposite direction) ✓
Correctly links to Newton's 3 rd law ✓

This force on the ship equals the drag force on the ship✓ Correctly links to Newton's 1st law ✓

Force is needed to change the water's momentum ✓ Correctly links to Newton's 2nd law✓

Must link correct law to at least one correct statement for all 4 marks

4

(c) (When system is enabled,) drag decreases by more than thrust

Or

(When system is enabled,) decrease in work done (per second) against drag (at any speed) is greater than the decrease in the work done by the propeller (at any rotational speed)✓

Work done (per second) by drag decreases and work done (per second) by propeller decreases (at any rotational speed) ✓

To maintain constant momentum then drag must equal thrust✓

Propeller can operate at lower rotational speed so that thrust again equals drag

Or

Engine does less work (and less fuel needs burnt) ✓

3rd MP: Accept answer in terms of power = Fv

3

[9]

2. (a) Use of $E_k = ½ mv^2$ ✓

(Kinetic energy =) 9.2×10^9 (J) ✓

Condone POT error on 1st MP

Allow use where v where has been converted from 5.5 km h^{-1}

An answer to 2 significant figures (with some working) ✓

Significant figure mark requires evidence of some relevant working.

3

(b) **Why force on the gas:**

The gas's momentum is changing ✓

This require a force according to **Newton's 2 nd law** ✓

Or

The gas is being accelerated ✓

This require a force according to **Newton's 2 nd law** ✓

Max 3 *for* ***why there is a force on the gas*** *and* ***why there is a resistive force on the system***

Must have ***why the system decelerates*** *to obtain all* ***4 marks****.*

The reason why the resultant force causes the deceleration rather than the acceleration.

Why (resistive) force on system:

The gas exerts a force on the parachute (with an equal magnitude and opposite direction force) / there is air resistance (on the system) / there is drag (on the system) / there is a resistive force (on the system) ✓

(because) the Parachute exerts a force on the gas according to **Newton's 3 rd law** ✓

Allow statement that is equivalent to N1 / N2 / N3.

Allow: air resistance (or drag) increases.

Allow: there is an upward force

must have a clear action-reaction pair for this ***N3*** *mark.*

Why system decelerates:

The resistive force is <u>greater than the weight</u> so there is a resultant force

Or

The **resultant** force is acting in the opposite direction (to its motion). ✓

acceleration in same direction as resultant force according to **Newton's 2 nd law** ✓

allow the ***resultant*** *force is vertically upwards*

Or

Links *to violation for conditions of Newton's 1 st law and therefore cannot continue at constant velocity.*

4

(c) Attempt at determining difference = 3.3 (× 10^5) − 2.2 (× 10^5) or difference = 1.1 (× 10^5) ✓

1st mark: Credit an application of conservation of energy (allow written statement, or equation without substitution)

Ignore signs on difference and answer.

MP2 allow their energy in a substitution that is, otherwise correct.

Condone an answer = 18.4 (m s^{-2}) is worth 2 marks.

Use of $E_p = mgh$ ✓

(g =) 3.7 (m s^{-2}) ✓

Condone mgh = ½ mv^2 where rearranged to make g subject.

Condone 610 x g x 49 = ***their energy***

Alternative:

- *Attempt to use appropriate equations of motion to determine acceleration*

$v^2=u^2+2as$ rearranged to make a the subject (condone use of their values for v and u and / or g = a)

- *Attempt to use W=Fs to determine the air resistance F_D (or F_D= 6734(.7) (N) seen)*
- *Attempt to determine g from the deceleration of the system*

$$g = \frac{F_D - ma}{m}$$

3

(d) More mass to **displace** / more particles to **collide with** / more gas / dust to displace ✓

Must have some interaction with parachute-spacecraft.

N/E to say there are more particles / gas / dust /mass

(at any given speed)
Greater (rate of) change of momentum / More work done (per unit distance) / Greater (resistive) force / more kinetic energy transferred (per unit distance) ✓

Greater **resultant** force **on** the system (therefore greater deceleration) / greater loss of velocity per second (therefore greater deceleration) ✓

3rd MP for greater resultant force: allow the idea that the difference between the drag and weight has increased

3rd MP
Allow clear statement that links:

- *rate of change of momentum of gas / dust to rate of change of momentum of system*
- *rate of work done on gas / dust to rate of work done by system*

3

[13]

3. (a) Attempt to calculate weight of cage
eg $1.2 \times 10^3 \times 9.81$ or 1.18×10^4 seen ✓

Attempt to find vertical component of tension T_V in one rope
eg $3.7 \times 10^4 \cos 20$ or 3.5×10^4 seen ✓

Uses F = twice their tension – their weight ✓

If weight not calculated, allow MP3 for doubling their tension or their resolved component

5.8×10^4 (N) ✓

4

(b) Use of $F = ma$ with 6×10^4 N or their (a) ✓
50 (m s^{-2}) ✓

Allow 48 (m s^{-2}).

2

(c) Calculation of length of rope
eg 35/cos20 or 37.2 seen ✓

Allow methods using $F = k\Delta L$ and $E = ½ k\Delta L^2$

Calculation of extension of one rope or calculation of total extension of both ropes
eg their length–24 or 13.2 or 26.4 seen ✓

Use of $E = ½ F\Delta L$
e.g. $½ \times 3.7 \times 10^4 \times 13.2 = 2.44 \times 10^5$ (J) ✓

4.9×10^5 (J) ✓

4

(d) Use of E lost = ΔE_p
eg $1.2 \times 10^3 \times 9.81 \times h = 5 \times 10^5$ ✓

No credit for use of suvat in either method and MP3 must come from correct Physics.

First method is for calculation of max h and comparison with 50 m.

h = 42 (m) ✓

Allow h from their (c) if it rounds to 5×10^5

42 < 50 (m), so claim not justified ✓

OR

Use of $\Delta E_p = mg\Delta h$ with 50 m
eg $1.2 \times 10^3 \times 9.81 \times 50$ ✓

Second method is for calculation of ΔE_p and comparison with E.

$\Delta E_p = 5.9 \times 10^5$ (J) ✓

$5.9 \times 10^5 > 5 \times 10^5$, so claim not justified ✓

3

(e) 90 km h^{-1} = 25 m s^{-1} ✓

The conversion mark stands alone.

1

Use of $E_k = ½ mv^2$
eg ½ × 1.2×10^3 × (their v)^2 ✓

3.8×10^5 (J) ✓

ecf for their v

2

(f) If their $E_k > 5 \times 10^5$, claim is unjustified

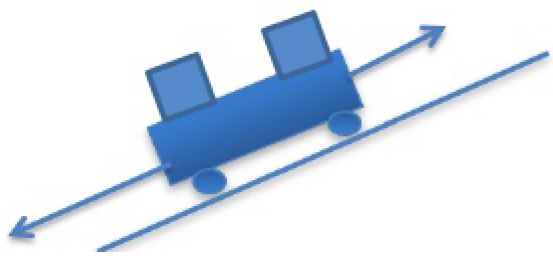
OR

If their $E_k < 5 \times 10^5$, claim may be justified depending on gain in E_p or losses due to resistive forces ✓

1

[17]

4. (a) arrow parallel to slope labelled (M+2m)gsin35 and label parallel to slope labelled tension OR T ✓



Ignore arrows not parallel to ground e.g. weight

Ignore friction

W not acceptable for (M +2m)g

1

(b) T – Mgsin35 = Ma
AND (M+2m)gsin35 – T = (M+2m)a ✓

add two equations

(M + 2m)gsin35 – Mg sin35 = Ma + (M +2m)a ✓

HENCE
(a= mgsin35 / (M+m))

OR
(M +2m)gsin35 – Mgsin35 ✓ (= (2M+2m)a)

a = 2mgsin35 /(2M +2m) ✓

HENCE
(a= mgsin35 / (M+m))

1
1

(c) SECOND MARK CONDITIONAL ON FIRST
mass / impulse / acceleration (of trollies) is the same ✓
momenta (trolley A and B) the same

SECOND MARK CONDITIONAL ON FIRST

both have same <u>speed / magnitude of velocity</u> but different masses ✓

(hence) momentum of A is greater / momenta in opposite directions ✓

1
1

(d) acceleration = $\frac{1}{4} \times \frac{30 \times 9.81 \times \sin 35°}{(30 + 95)} = 0.338$ ✓

(use of $v^2 = 2as$)

$v = \sqrt{(2 \times 0.338 \times 9.0)} = 2.47$ ✓

$t = \frac{2.47}{0.338} = 7.3\text{s}$ ✓

OR
(use of $s = 1/2at^2$)
$9 = ½ \times 0.338 \times t^2$ ✓
$t = 7.3$ s ✓

CE from acceleration calculation

If used g for acceleration then no marks awarded

1
1
1

(e) number of journeys = (1800/(12 + 7.3) = 93 or 94 ✓

number of blocks = 2 × 93 = 186 or 2 × 94 = 188 ✓

Allow CE from 06.4

Allow between 93 to 94

Allow CE from incorrect number of journeys

Allow 186 to 188

1
1

[10]