A-Level Physics

Scalars and Vectors

Mark Scheme

Time available: 88 minutes
Marks available: 63 marks

1.

(a) States tension in **P** + tension in **Q** = 750 + 1800

OR

tension in **Q** = 1400 N

OR

Distance from **Q** = 3.6 − d ✓

Use of principle of moments ✓

(d =) 2.4 (m) ✓

alternative

*Finds component of tension in **P** due to worker's weight = 250 N / Finds tension in **P** (due to weight of worker) by dividing weight of platform by 2 and subtracts from 1150 N*

OR

*Finds component of tension in **Q** due to worker's weight = 500 N / Finds tension in **Q** (due to weight of worker) by dividing weight of platform by 2 and subtracts from 1400 N* ✓

*Recognises the ratio of weight distribution to worker position relative to cables **P** and **Q***

250 N : 500 N = 3.6 − d : d ✓ (principle of moments)

(d =) 2.4 (m) ✓

3

(b) Extension = 0.18 m or use of $\varepsilon = \frac{\Delta L}{L}$ or reads off *d* correctly for their extension ✓

(d =) 1.8 m ✓

2

(c) (σ =) 1.14 × 10^7 (N m^{-2}) ✓ c.a.o

1

(d) Straight line with negative gradient ✓

Line passes through (0, 0.46) ✓

Line passes through (3.6, 0.26) ✓

3

[9]

2. (a) Volume = area × length = 4.16×10^{-4} m^3 ✓

Mass correct = W/g = 3.6 kg ✓
To give density 8.6×10^3
And therefore brass ✓

Alternative for MP2 and MP3
(for brass)
Mass of brass = density × volume = 3.58 kg✓
Weight = 3.58 × 9.81 = 35 N
And therefore brass is correct. ✓

3

(b) Use of T = 2 (35) cos 55 ✓
= 40 N ✓

Allow 1 max for any one error

2

(c) Weight/tension in rope still 35 N OR is constant ✓

Angle to horizontal decreases so cos(angle) increases ✓

(Therefore tension in cable must increase)

Allow reference to
T *= 2(35) cos (angle) for MP2*

2

(d) Component at right angle to door =

41 cos (90−12)

= 8.5 N ✓

Moment = 8.5 × 0.95 = 8.1 (N m) ✓

Alternative:
Perpendicular distance = 0.95 sin (12)
= 0.198 m ✓
Moment = 41 × 0.198 = 8.1 ✓

2

(e) Increase weight of **A** ✓

Increases tension and therefore moment ✓

Position pulley **R** further from pillar ✓

Increases angle and therefore bigger perpendicular component and therefore moment. ✓

Any 2 pairs

Condone (without discussion of effect on angle)

*Move **D** further from hinge* ✓

Increases perpendicular distance and therefore moment ✓

4

[13]

3. (a) Closed triangle of forces drawn ✓

Appropriate scale ✓

θ = 23 to 27 (°) ✓

U = 77 to 81 (N) ✓

Accept scale where 10 N is represented by at least 1 cm.

Treat each marking point independently.

Do not accept answers for U and θ without a scale diagram.

Maximum of 3 marks for a free-body diagram where forces have been drawn to scale. (Check figure 8)

4

(b) V is vertical / Force at **Y** is now vertical / V does not have a horizontal component / $V = S + 31$ / V is perpendicular to the pole / V is of greater magnitude than U / Force at **Y** has increased in magnitude✓

(Because) S and weight (or *mg*) are both vertical (in **Fig 3**)✓

(Because) greater moment of weight (about **Y**) in **Fig 3** / smaller moment of weight (about **Y**) in **Fig 1** / (Because) S is larger in magnitude than D (to produce a greater moment (about **Y** because they are equal distances from Y)✓

3

[7]

4. (a) 0.56 (N) ✓

1

(b) Definition of couple as two <u>equal</u> forces acting in opposite directions ✓

Moment of a couple is independent of the point about which moments are taken ✓

Forces (are equal but) don't act in opposite directions, therefore it is not correct ✓

Combined moment of the two forces depends on the point about which moments are taken, therefore not correct. ✓

2

(c) Use of total upward force = total downward force

1 mark for any attempt to equate upward and downward forces. Response may be on diagram.

eg 0.87 + 0.62 = 1.12 + W ✓

0.32 (N) ✓

Attempt to use Principle of Moments ✓

0.14 (m) ✓

Allow MP4 if (their W) × (their d) = 0.0448

4

(d) Readings (on A and B) would be the same/1.44 (N) ✓

(Because) total downwards force/weight is same

OR

All (perpendicular) distances affected by the same factor

(cos θ) ✓

2

[9]

5. (a) The centre of mass of the beam and box is at the pivot ✓

Idea that moments balance / sum of the moments is zero at this position ✓

OR

The anticlockwise moment (of weight of the beam) = clockwise moment (of weight of the box) ✓

Links pivot position to a consideration of moments ✓

Accept one route or the other, do not accept points from both.

Allow max 1 for "the pivot is to the right of the centre (of mass) of the beam"

'pivot' on its own does not get the first mark

Award 2 for 1.25 × weight of beam = 1.5 × weight of empty box

Confusion of moments with eg work done/forces = max 1

2

(b) Clockwise moment = 610 × 9.81 × 1.5 (= 8976 N m) ✓

Anticlockwise moment = 250 × 4 + T sin 50 × 4.0 (N m)✓

Use of clockwise = anticlockwise✓

Use of T sin 50° seen / relates vertical component to tension✓

T (= 1994/sin 50°) = 2600 (N)✓

Credit any evidence to work out a moment with one mark

Condone cos 50 in MP2.

Allow ecf for clockwise moment

Allow ecf for anticlockwise moment

Use of g = 10 N kg^{-1} gives 2990 N Omission of 4.0 m (g = 9.8) gives 10410 N. Use of cos 50 (g = 9.8) gives 3100 N

Allow max 4 for use of g = 10 N kg^{-1}.

5

(c) 7.5 = ½ g t^2 ✓

(t = 1.2 s)

(calculate distance)

s (= ut = 18 × 1.2) = 22 (m)✓

Allow ecf from incorrect t for MP2

2

(d) **(Range will be greater:)**

component of velocity upwards ✓

rock will spend longer in the air ✓

greater *t* ✓

therefore the range is greater ✓

OR

(Range will be smaller)

Counterweight will fall less far before projectile released ✓

Less energy transferred to rock ✓

Initial speed of rock less/horizontal velocity reduced ✓

therefore the range is smaller ✓

OR

(balanced arguments)

therefore the range is unchanged / answer is indeterminate ✓

Candidates can argue from both lists to reach a balanced view suggesting that there is no change.

Full credit can be obtained from 2 deductions from one list ✓✓+ consistent conclusion ✓

1 deduction from each list ✓✓+ consistent conclusion ✓

Do not allow an unsupported conclusion.

*Conclusion must be consistent with **correct** statements.*

Treat incorrect statements as neutral.

Do not reward arguments based on a longer time of flight.

MAX 3

[12]

6. (a) (component of total weight parallel to slope =) 640 sin θ ✓

Allow mg sin θ or 65g sin θ

1

(b) use of $P = Fv$ ✓

(θ =) 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 θ has decreased ✓

mg sin θ 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]