# Equations of Motion

## Mark Scheme 3

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| **Level** | International A Level |
| **Subject** | Physics |
| **Exam Board** | CIE |
| **Topic** | Kinematics |
| **Sub Topic** | Equations of Motion |
| **Paper Type** | Theory |
| **Booklet** | Mark Scheme 3 |

**Time Allowed:** **78 minutes**

**Score:** **/65**

**Percentage:** **/100**

| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

| | | | | | |
|---|---|---|---|---|---|
| 1 | **(a** | **(i)** | **1.** distance of path / along line AB | B1 | [1] |
| | | | **2.** shortest distance between AB / distance in straight line between AB or displacement from A to B | B1 | [1] |
| | | **(ii)** | acceleration = rate of change of velocity | A1 | [1] |
| | **(b)** | **(i)** | distance = area under line or $(v/2)t$ or $s = (8.8)^2 / (2 \times 9.81)$ | C1 | |
| | | | $= 8.8 / 2 \times 0.90 = 3.96\,\text{m}$ or $s = 3.95\,\text{m} = 4(.0)\,\text{m}$ | A | [2] |
| | | **(ii)** | acceleration $= (-4.4 - 8.8) / 0.50$ | C1 | |
| | | | $= (-)\ 26(.4)\,\text{m s}^{-2}$ | A1 | [2] |
| | **(c)** | **(i)** | the accelerations are constant as straight lines | B1 | |
| | | | the accelerations are the same as same gradient or no air resistance as acceleration is constant or change of speed in opposite directions (one speeds up one slows down) | B1 | [2] |
| | | **(ii)** | area under the lines represents height or KE at trampoline equals PE at maximum height | B1 | |
| | | | second area is smaller / velocity after rebound smaller hence KE less | B1 | |
| | | | hence less height means loss in potential energy | A0 | [2] |

2 **(a** work done is the force × the distance moved / displacement in the direction of the force
*or*
work is done when a force moves in the direction of the force — B1 [1]

**(b)** component of weight = 850 × 9.81 × sin 7.5° — C1
= 1090 N — A1 [2]
(*use of incorrect trigonometric function, 0/2*)

**(c)** $\Sigma F$ = 4600 – 1090 = (3510) — M1
deceleration = 3510 / 850 — A1
= 4.1 m $s^{-2}$ — A0 [2]

**(ii)** $v^2 = u^2 + 2as$
$0 = 25^2 + 2 \times -4.1 \times s$ — C1
$s$ = 625 / 8.2
= 76 m — A1 [2]
(*allow full credit for calculation of time (6.05 s) & then s*)

**(iii)** **1.** kinetic energy = ½ $mv^2$ — C1
= 0.5 × 850 × $25^2$
= 2.7 × $10^5$ J — A1 [2]

**2.** work done = 4600 × 75.7
= 3.5 × $10^5$ J — A1 [1]

**(iv)** difference is the loss in potential energy (*owtte*) — B [1]

| | | | | |
|---|---|---|---|---|
| 3 | **(a** | scalar has only magnitude | B1 | |
| | | vector has magnitude and direction | B1 | [2] |
| | **(b)** | kinetic energy, mass, power all three underlined | B1 | [1] |
| | **(c)** **(i)** | $s = ut + ½ at^2$ | | |
| | | $15 = 0.5 \times 9.81 \times t^2$ | C1 | |
| | | $T = 1.7$ s | A1 | [2] |
| | | if $g = 10$ is used then –1 but only once on paper | | |
| | **(ii)** | vertical component $v_v$: | | |
| | | $v_v^2 = u^2 + 2as = 0 + 2 \times 9.81 \times 15$ or $v_v = u + at = 9.81 \times 1.7(5)$ | | |
| | | $v_v = 17.16$ | C1 | |
| | | resultant velocity: $v^2 = (17.16)^2 + (20)^2$ | C1 | |
| | | $v = 26$ m s$^{-1}$ | A1 | [3] |
| | | If $u = 20$ is used instead of $u = 0$ then 0/3 | | |
| | | Allow the solution using: | | |
| | | initial (potential energy + kinetic energy) = final kinetic energy | | |
| | **(iii)** | distance is the actual path travelled | B1 | |
| | | displacement is the straight line distance between start and finish points (in that direction) / minimum distance | B1 | [2] |
| 4 | **(a** | acceptable straight line drawn (touching every point) | B1 | [1] |
| | **(b)** | the distance fallen is not *d* | C1 | |
| | | *d* is the distance fallen plus the diameter of the ball | A1 | [2] |
| | | ('d is not measured to the bottom of the ball' scores 2/2) | | |
| | **(c)** **(i)** | diameter: allow 1.5 ± 0.5 cm (accept one SF) | A1 | [1] |
| | | no ecf from **(a)** | | |
| | **(ii)** | gradient = 4.76, ± 0.1 with evidence that origin has not been used | C1 | |
| | | gradient = $g$ / 2 | C1 | |
| | | $g = 9.5$ m s$^{-2}$ | A1 | [3] |

| | | | | | |
|---|---|---|---|---|---|
| 5 | **(a)** | **(i)** | $E = V / d$ | C1 | |
| | | | $= 350 / (2.5 \times 10^{-2})$ | | |
| | | | $= 1.4 \times 10^{4}$ N $C^{-1}$ | A1 | [2] |
| | | **(ii)** | force = $Eq$ | C1 | |
| | | | $= 1.$ $^{4}$ × 1 $^{-19}$ | M1 | |
| | | | $= 2.24 \times 10^{-15}$ | A0 | [2] |
| | **(b)** | **(i)** | $F = ma$ | C1 | |
| | | | $a = (2.24 \times 10^{-15}) / (9.1 \times 10^{-31})$ | | |
| | | | $= 2.4$ $^{15}$ m $^{-2}$ …(*allow* × $10^{5}$) | A1 | [2] |
| | | **(ii)** | $s = ½at^2$ | C1 | |
| | | | $2.5 \times 10^{-2} = ½ \times 2.46 \times 10^{15} \times t^2$ | | |
| | | | $t = 4.5 \times 10^{-9}$ s | A1 | [2] |
| | **(c)** | | *either* gravitational force is normal to electric force<br>*or* electric force horizontal, gravitational force vertical | B2 | [2] |
| | | | *special case:* force/acceleration due to electric field >> force/acceleration due to gravitational field, allow 1 mark | | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | **(a** | | kg m $s^{-2}$ | B1 | **[1]** |
| | **(b)** | | kg $m^{-1}$ $s^{-1}$ | B1 | **[1]** |
| | **(c)** | **(i)** | $v^2 = 2gs$ | | |
| | | | $= 2 \times 9.8 \times 4.5$ | C1 | |
| | | | $v = 9.4$ m $s^{-1}$ | A1 | **[2]** |
| | | **(ii)** | *either* | | |
| | | | $F$ (= $3.2 \times 10^{-4} \times 1.2 \times 10^{-2} \times 9.4$) = $3.6 \times 10^{-5}$ N | M1 | |
| | | | weight of sphere (= $mg$ = $15 \times 10^{-3} \times 9.8$) = 0.15 N | M1 | |
| | | | $3.6 \times 10^{-5}$ << 0.15, so justified | A1 | **[3]** |
| | | | *or* | | |
| | | | $mg = crv_T$ (M1) | | |
| | | | terminal speed = $3.8 \times 10^{4}$ m $s^{-1}$ (M1) | | |
| | | | $9.4 << 3.8 \times 10^{4}$, so justified (A1) | | |

7 **(a)** **(i)** acceleration (allow a definition of acceleration) ..... B1

**(ii)** the velocity is decreasing or force/acceleration is in negative direction – accept 'body is decelerating'/'slowing down' ..... B1 [2]

**(b)** **(i)** e.g. separation of dots becomes constant/does not continue to increase (must make a reference to the diagram) ..... B1

**(ii)** distance = 132 cm ..... B1

**(ii)** at constant speed, distance travelled in 0.1 s = 25 cm (allow ± 1 cm) ..... C1
distance = 132 + (4 x 25)
= 232 cm ..... A1 [4]

**(c)** $s = ut + ½at^2$
$1.6 = ½ \times 9.8 \times t^2$ (allow $g = 10$ m $s^{-2}$ ..... C1
$t = 0.57$ s ..... C1
hence 6 photographs ('bald' answer scores 2 marks only) ..... A1 [3]