Year 12 Physics **TEST # 1 – Gravity & Motion I** **2022**

NAME: SOLUTIONS

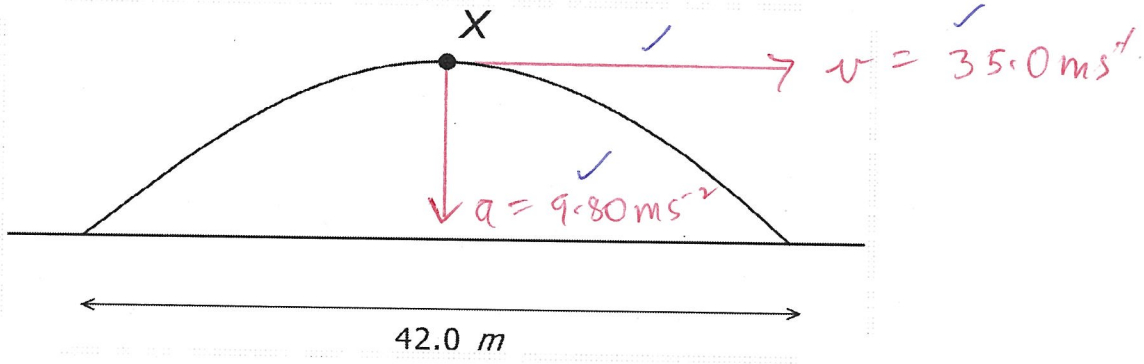
Total Marks: 36 *Time Allowed: 45 minutes*

(Formula sheet and scientific calculator permitted)

Ignore frictional effects in all questions in this test.

Question 1 **(3 marks)**

The diagram shows the trajectory of a soccer ball kicked from ground level from left to right. Point *X* is the highest point of the trajectory. The ball spends 1.20 s in the air.



Draw labelled vectors on the diagram at point *X* showing the direction of the ball's velocity and acceleration at that point, and write the magnitude on each vector.

$v = \frac{s}{t} = \frac{42}{1.2} = 35.0\ ms^{-1}$

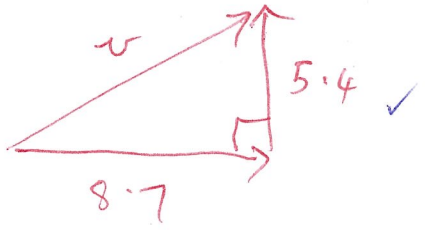
3

3

Question 2 **(8 marks)**

At one point in its trajectory, a cricket ball of mass 0.160 kg, originally hit from ground level, has a horizontal speed of 8.70 ms^{-1} and a vertical speed of 5.40 ms^{-1}.

(a) What is the ball's total kinetic energy at this point? [3]



$v^2 = 8.7^2 + 5.4^2$ ✓

$= 104.85$ ✓

3

$\therefore E_K = \frac{1}{2}mv^2$

$= 0.5 \times 0.16 \times 104.85$

$= 8.39\,J$ ✓

[can also do separate $\frac{1}{2}mv^2$ calculations → 8.39 J]

(b) How much higher will the ball rise from this point? [3]

Vert.

$u = 5.4$

$a = -9.8$

$v = 0$

$s = ?$ ✓

$v^2 = u^2 + 2as$

$0 = 5.4^2 - 2 \times 9.8\,s$ ✓

$19.6s = 29.16$

$\therefore s \approx 1.49m$ ✓

3

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(c) What is the ball's kinetic energy at its highest point? [2]

$E_k = \frac{1}{2}mv^2$

$= 0.5 \times 0.16 \times 8.7^2$ ✓

$\simeq 6.06$ J ✓ (2)

See next page for Question 3

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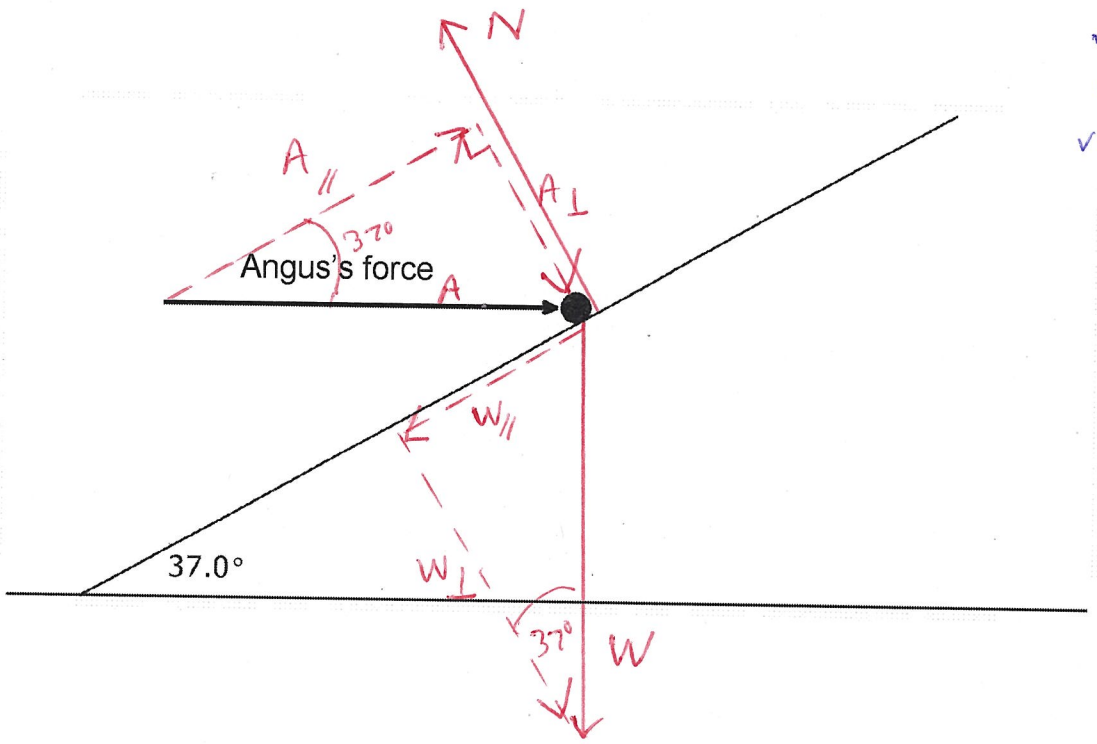
Question 3 **(13 marks)**

Angus holds a small sphere of mass 120.0 g on a smooth plane inclined at 37.0° to the horizontal by applying a horizontal force, as shown below:



✓ Normal
✓ Weight
✓✓ cpts

4

(a) Show and label, on the diagram above, all forces acting on the sphere and draw the components of these forces parallel and perpendicular to the plane. [4]

(b) Determine the magnitude of Angus's force. [4]

$W = mg = 0.12 \times 9.8 = 1.176\,N$ ✓

$\therefore W_{//} = 1.176 \sin 37° \approx 0.7077\,N$ ✓

$\therefore A_{//} = 0.7077\,N$ ✓

i.e. $A\cos 37° = 0.7077$

$\therefore A \approx 0.886\,N$ ✓

4

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(c) What is the magnitude of the normal reaction force of the plane on the sphere? [3]

N balances both $A_\perp$ and $W_\perp$ ✓ ✓

$\therefore N = 0.886 \sin 37° + 1.176 \cos 37°$

≈ 1.47 N ✓

3

(d) Angus could apply a smaller force to hold the sphere in place if he pushed in which direction? Justify your answer. [2]

Straight up the plane. ✓

Then all of his force balances $W_{//}$ instead of only a component of his force. ✓

2

[He could also push at any angle to the plane $< 37°$, but $0°$ is optimal.]

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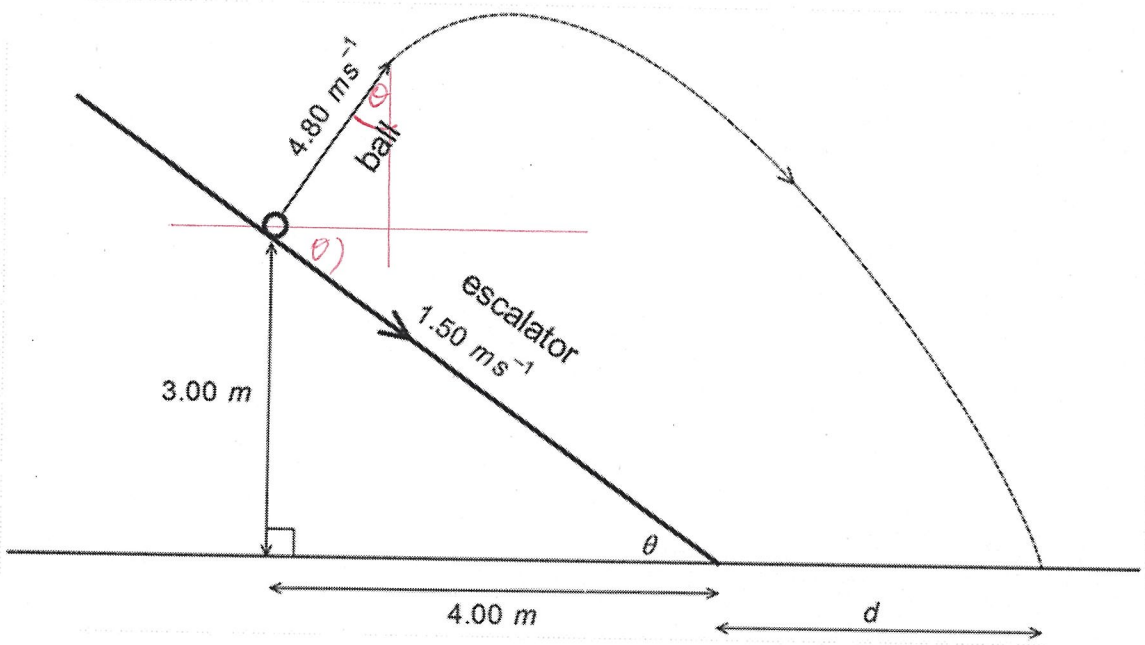
Question 4

(12 marks)

A child on an escalator moving downwards at 1.50 ms^{-1} throws a ball at 4.80 ms^{-1} (relative to the escalator) at right angles to the motion of the escalator, as shown in the diagram below.



Calculate the distance *d* indicated in the diagram.

(Hint: First find the angle θ and then the horizontal and vertical components of the 1.50 ms^{-1} velocity and the 4.80 ms^{-1} velocity.)

$\tan\theta = \frac{3}{4} \Rightarrow \theta \approx 36.87°$ ✓

Cpts of $1.50\ ms^{-1}$ vel.: ✓

Hor. $= 1.5 \cos 36.87° = 1.20\ ms^{-1}$

Vert. $= 1.5 \sin 36.87° = 0.900\ ms^{-1}$ ✓

(more working space on next page)

3

(Working space for Question 4)

Cpts of 4·80 ms^{-1} vel.:

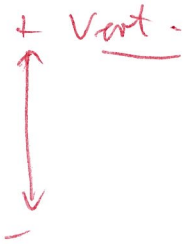
Hor. $= 4{\cdot}8 \sin 36{\cdot}87° = 2{\cdot}88$ ms^{-1} ✓

Vert. $= 4{\cdot}8 \cos 36{\cdot}87° = 3{\cdot}84$ ms^{-1} ✓

∴ Cpts of ball's resultant vel.:

$u_H = 2{\cdot}88 + 1{\cdot}2 = 4{\cdot}08$ ms^{-1} ✓

$u_V = 3{\cdot}84 - 0{\cdot}9 = 2{\cdot}94$ ms^{-1} ✓



$u = 2{\cdot}94$

$s = -3$

$a = -9{\cdot}8$

$t = ?$ ✓

$v^2 = u^2 + 2as$

$= 2{\cdot}94^2 + 2 \times 9{\cdot}8 \times 3$

$= 67{\cdot}4436$

$\therefore v \simeq -8{\cdot}212$ ms^{-1} ✓

$v = u + at$

$-8{\cdot}212 = 2{\cdot}94 - 9{\cdot}8t$

$\therefore t \simeq 1{\cdot}138$ s ✓

Hor. $s = u_H t = 4{\cdot}08 \times 1{\cdot}138 = 4{\cdot}643$ m ✓

$\therefore d = 4{\cdot}643 - 4$

$= 0{\cdot}643$ m. ✓

- End of Questions -

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