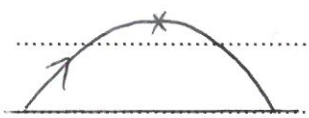
CORPUS CHRISTI COLLEGE SEQUERE DOMINUM	Year 12 *ATAR* Physics Unit 3 2017 *Test 1* *Projectile Motion,* *3.0%* **NAME:** ..... Solns ..... Data: See Data Sheet Approx. marks shown. *(52 marks)*

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

1. A person on the tray of a truck travelling at 40.0 kmh^{-1} in a straight line throws a ball straight up at 8.00 m s^{-1} and catches it again at the same height. What horizontal displacement does the ball undergo whilst in flight? [4]



Horiz: $s = vt$

$= 11.11 \times t$

$40 kmh^{-1} / 3.6 = 11.11 ms^{-1}$ ✓ Vert: $u = 8 ms^{-1}$ $v = 0$ $a = -9.8 ms^{-2}$ $t = ?$

(mid pt) $v = u + at$

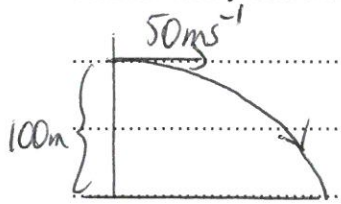
$0 = 8 + (-9.8)t$ ✓

$t = 8/9.8 = 0.8163 s$

$\therefore$ Horiz displ $= 11.11 \times (0.8163 \times 2)$ ✓ $= 18.14 m$

$= 18.1 m$ (3sf) ✓

2. A cannon fires a cannon ball horizontally at speed of 50.0 m s^{-1} from the top of a bridge that is 100 m above the surface of a lake below. Ignoring air resistance, calculate the velocity of the cannon ball just before it hits the water. [5]



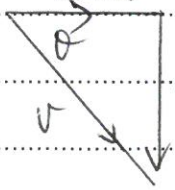
Note: lands at an angle.

Horiz: $v = 50 ms^{-1}$

Vert. $v^2 = u^2 + 2as$ ✓

$= 0 + 2(9.8)(100)$ ✓

$v = \sqrt{1960} = 44.27 ms^{-1}$ ✓



$v^2 = 44.27^2 + 50^2$ ✓

$v = \sqrt{4460} = 66.78 ms^{-1}$ ✓

$\tan\theta = \frac{44.27}{50}$ $\therefore \theta = \tan^{-1}(\ ) = 41.52°$

$\therefore$ Vel at water = 66.8 ms^{-1}, 41.5° below horiz.

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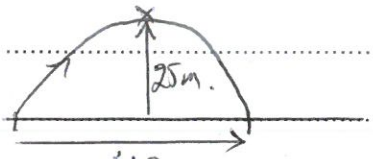
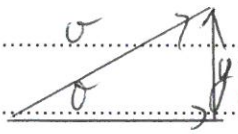
3. A cricket ball (hit from near the ground) strikes the ground just over the boundary 110 m from the batsman. A spectator estimates that the ball rose to a maximum height of 25 m.
Use calculations to estimate the velocity with which the ball left the bat. [6]



Horiz: $s = vt$

$110 = vt$

Vel: $s = 25$ m, $v = 0$, $a = -9.8\,ms^{-1}$, $u = ?$



(mid pt) $v^2 = u^2 + 2as$

$0 = u^2 + 2(-9.8)(25)$

$u = \sqrt{490} = 22.14\,ms^{-1}$ ✓

and $v = u + at$

$0 = 22.14 + (-9.8)t$ ✓

$t = 22.14/9.8 = 2.259$ s ✓

Horiz $s = vt$

$110 = v(2.259 \times 2)$ ✓

$v = 24.347\,ms^{-1}$ ✓

Now $V^2 = 22.14^2 + 24.347^2 =$

$V = \sqrt{1082} = 32.91\,ms^{-1}$

and $\tan\theta = \frac{22.14}{24.347}$ ∴ $\theta = 42.28^\circ$ ✓ ($V = 33\,ms^{-1}$ ✓, 42° (2sf))

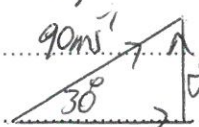
∴ initial vel = $32.9\,ms^{-1}$, 42.3° above horiz.

4. An arrow is fired at 30.0° above the horizontal with a speed of 90.0 m s^{-1}. Neglect air resistance and consider the arrow to be a point mass.

Figure 1

(a) (i) At what instant in time after firing will the arrow be travelling the slowest? [2]

Travels the slowest at the top of trajectory since only the horiz component present.



✓ At highest point $V = 0$, $u = 45\,ms^{-1}$, $a = -9.8\,ms^{-2}$, $t = ?$

$V = u + at$

$0 = 45 + (-9.8)t$ ✓

$t = \frac{45}{9.8} = 4.59$ sec.

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(ii) What is the velocity of the arrow at this instant of time? [2]

Horiz vel only = 77.9 ms⁻¹ parallel to ground OR tangent to curve OR horizontal

90 ms⁻¹, 30°

$x = 90\cos 30^\circ = 77.94\ ms^{-1}$

(b) Even though the target is at the same level as the bow when the arrow is released the arrow is not fired directly along the line of sight (the **blue line** in Figure 2 below). Briefly explain the reason for this. [3]

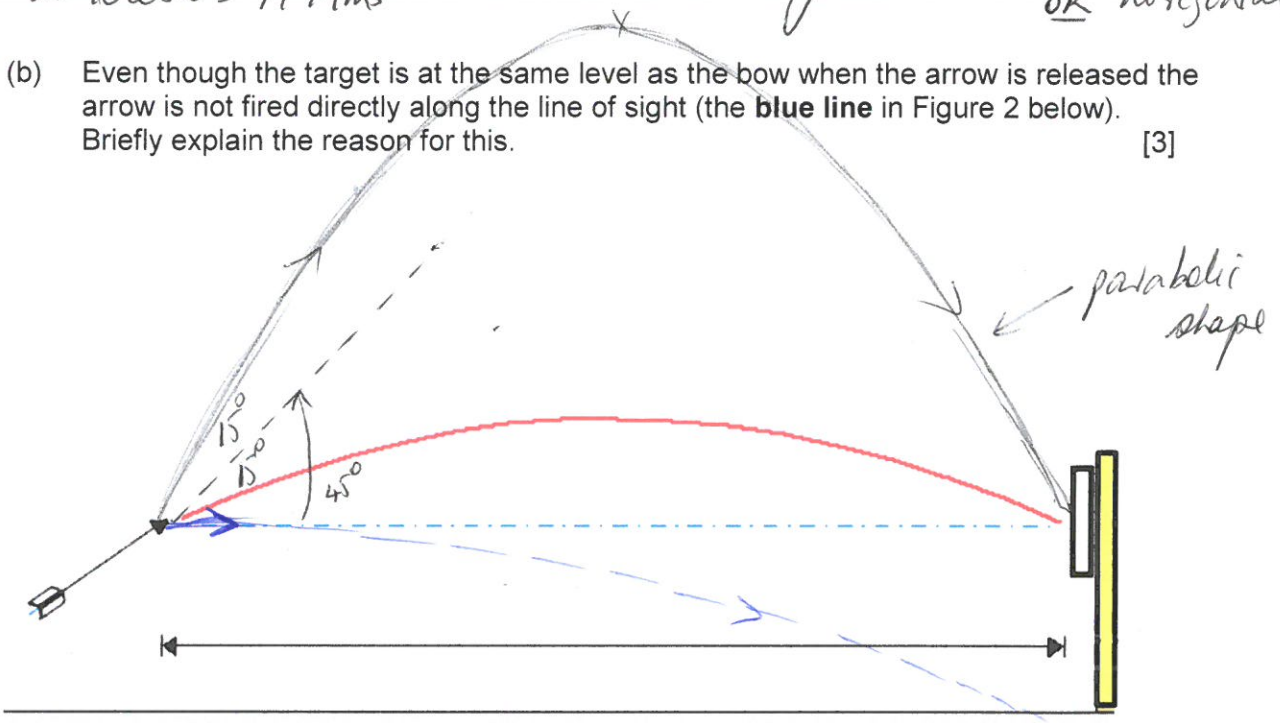

Figure 2

If the arrow was fired along the blue line it would follow a half parabolic trajectory + land below the target. (See blue)

Firing above the horiz increases the time that the arrow is in the air. This enables the arrow to travel a greater horiz distance before hitting the target.

(c) At what different angle could the arrow be fired to achieve the same range? Show the trajectory on **Figure 2** [2]

$45^\circ - 30^\circ = 15^\circ$ ∴ $\phi = 45 + 15 = 60^\circ$ above horiz

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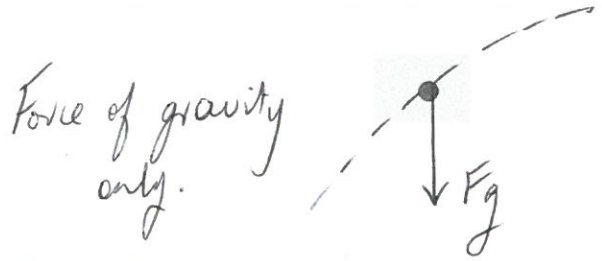
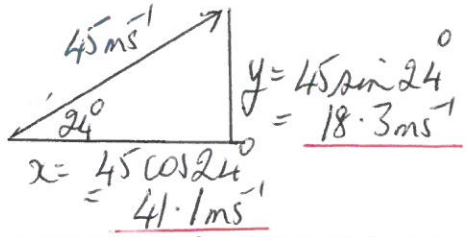
5. On February 6 1971, during the Apollo 14 mission, astronaut Alan Shepard hit a golf ball on the Moon. The golf club launched the ball at an angle of 24° to the ground with an initial speed of 45 m s^{-1}.

(a) Construct a labelled free body diagram below, showing the force(s) acting on the golf ball about halfway between it being struck and its highest point. [2]



(b) Calculate the horizontal and vertical components of the initial velocity. [2]



Answer u_h ..41.1.. m s^{-1}

Answer u_v ..18.3.. m s^{-1}

(c) Assuming the golf ball travelled over a level surface, a horizontal distance of 900 m, calculate

(i) time taken to hit the surface [2]

Horiz: $s = vt$

$900 = 41.1 \times t$

$t = 21.9$ s

(ii) the value of the acceleration due to gravity on the Moon [4]

Vert: $s = ut + \frac{1}{2}at^2$

$0 = 18.3(21.9) + \frac{1}{2}(-a)(21.9)^2$

$0 = 400.77 - 239.8a$

$a = \frac{400.77}{239.8}$

$g_{moon} = 1.67$ ms^{-2} (down to centre of Moon)

OR $v = u + at$

$0 = 18.3 + (-a)\left(\frac{21.9}{2}\right)$

$a = \frac{18.3}{10.95}$

$g_{moon} = 1.67 ms^{-2}$

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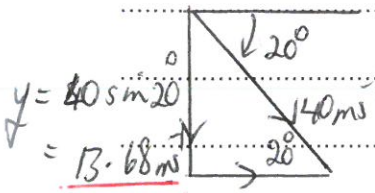
6. An explosion in a tall building projects window glass outward *and downward* at 40.0 m s^{-1} at an angle of 20.0° below the horizontal. If the glass strikes the ground 4.50 s later,

(a) how far from the ground was the room in which the explosion occurred, and [3]



$y = 40 \sin 20$
$= 13.68 \text{ ms}^{-1}$ ✓

Vert (Note: 'u' and 'a' in same direction)

$s = ut + \frac{1}{2}at^2$ ✓
$= 13.68(4.50) + \frac{1}{2}(9.8)(4.50)^2$
$= 160.785 \text{ m}$ ✓
$= 1.61 \times 10^2 \text{ m}$ (3sf)

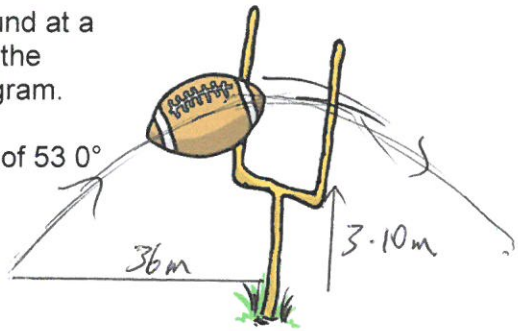
(b) how far from the base of the building does the glass land? [3]

$x = 40 \cos 20°$ ✓
$= 37.59 \text{ ms}^{-1}$ ✓

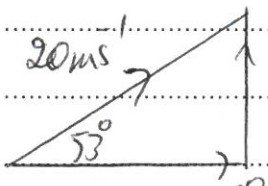
Horiz: $s = vt$ ✓
$= 37.59 \times 4.50$
$= 169 \text{ m}$ ✓ (3sf)

7. In a football game, a place kicker kicks a football from the ground at a distance of 36.0 m from the goalposts, and the ball must clear the crossbar which is 3.10 m from the ground as shown in the diagram.

When kicked, the ball leaves the foot at 20.0 m s^{-1} at an angle of 53 0° to the horizontal.



(a) How long does the ball take to travel the distance to the goalposts? [3]



$x = 20 \cos 53° = 12.0 \text{ ms}^{-1}$ ✓

Horiz $s = vt$ ✓
$36 = 12t$
$t = 3.00 \text{ s}$ (3sf) ✓

(b) How far above or below the crossbar is the ball when it passes through the goal posts? [4]

$y = 20 \sin 53°$
$= 15.97 \text{ ms}^{-1}$ ✓

Vert: $s = ut + \frac{1}{2}at^2$ ✓
$= 15.97 \times (3) + \frac{1}{2}(-9.8)(3.00)^2$ ✓
$= 3.81 \text{ m}$ ✓

∴ Passes over the bar by $3.81 - 3.10$ ✓
$= 0.710 \text{ m}$.

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(b) How far above or below the crossbar is the ball when it passes through the goal posts? [4]

.....

.....

.....

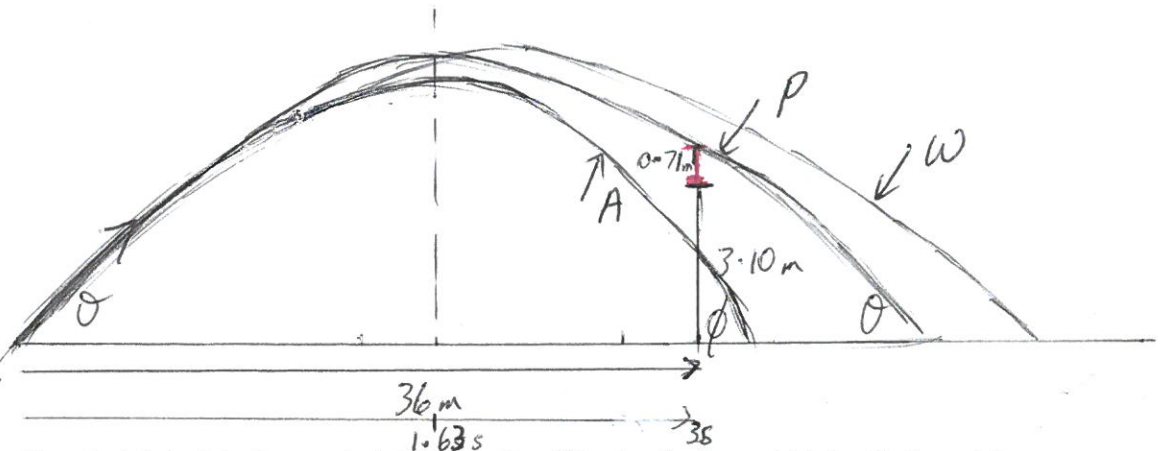
.....

.....

(c) Show on a sketch the path of the football. Include the goalposts in your sketch. Explain why you have drawn the path this way, *showing any necessary working*.
Label this path P. [5]

Is the ball on the way up or down at the bar?
Time to the highest pt?
Vert $v = u + at$
$0 = 15.97 + (-9.8)t$ ✓ ✓
$t = 1.63$ sec. ∴ ball coming down.

Note: P is perfect parabola.



All 3 paths start with same velocity.

(d) On the sketch in (c) above sketch the path of the football would take if air resistance was not negligible.
Label this path A. [2]

Shorter range, Highest pt beyond mid pt
Lower height, Lands steeper than launch.

(e) On the sketch in (c) above sketch the path of the football would take if a tail-wind was present and the air resistance was negligible.
Label this path W. [2]

same height
greater range
(lands at a shallower angle).

9.