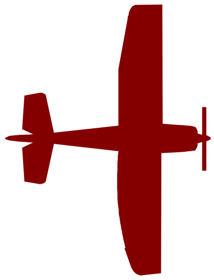
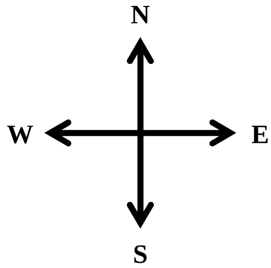
	ALL SAINTS' COLLEGE **Ewing Avenue, Bull Creek, Western Australia**
	12 Physics 3A 3B Motion & Forces Practice Test 1

Student Name: Solutions

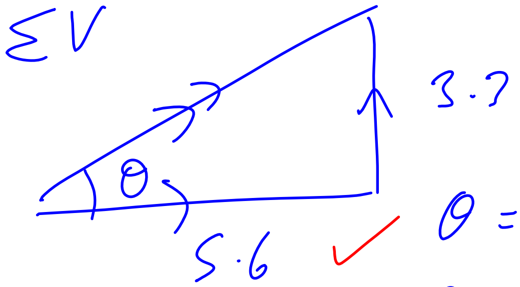
Time allowed: 45 minutes Total marks available: 45 Show calculation answers to 3 significant figures

1. A model plane is flying East at 5.60 m s^{-1} when it is hit by a wind acting North at 3.30 m s^{-1}.





a) Calculate the resultant velocity (magnitude and direction) of the plane in the wind. You **must** use a vector diagram in your answer. (3)



$\Sigma V^2 = 5.6^2 + 3.3^2$

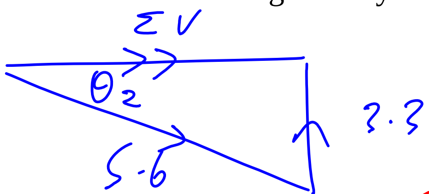
$\Sigma V = 6.50 \text{ m s}^{-1}$

$\theta = \tan^{-1}\left(\frac{3.3}{5.6}\right)$

$\theta = 30.5°$

$\Sigma V = 6.50 \text{ m s}^{-1}$ E 30.5° N

b) What direction should the plane point to achieve a resultant velocity in a direction due East. You must use a vector diagram in your answer. (2)

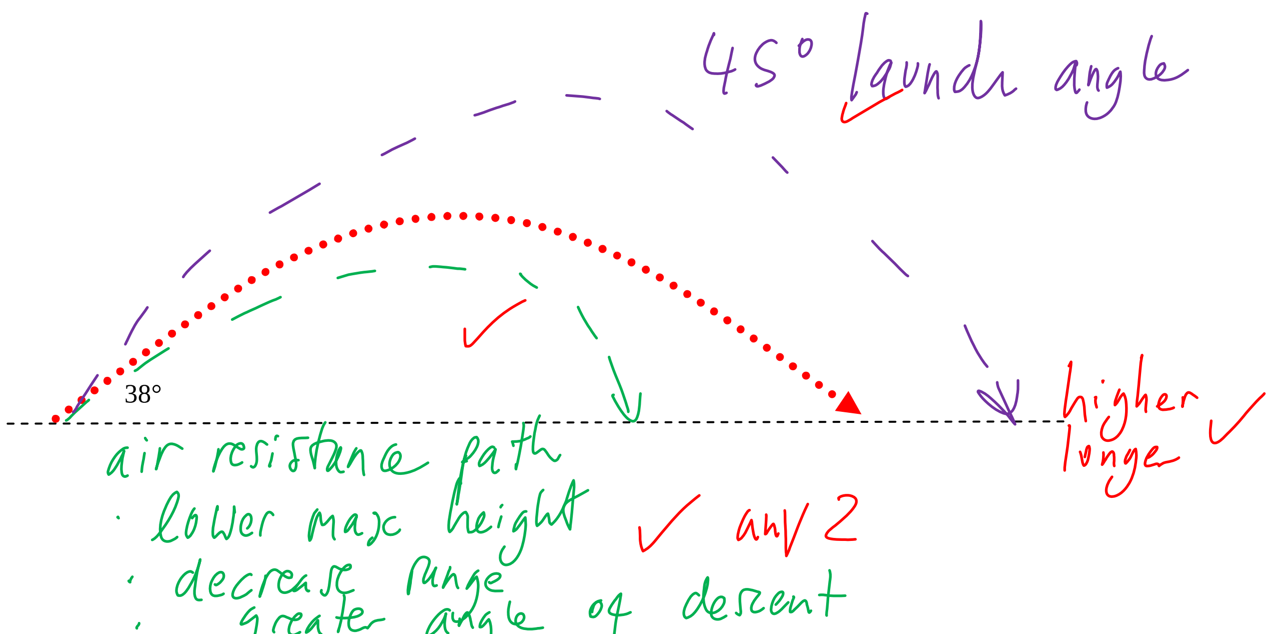


$\theta_2 = \sin^{-1}\left(\frac{3.3}{5.6}\right)$

$\theta_2 = 36.1°$

Direction = E 36.1° S

2. The ideal flight path, ignoring air resistance, of a golf ball launched at an angle of elevation of 38.0° is shown in the diagram below. The initial speed of the golf ball is fixed.



a) If air resistance *is present* show how the ideal flight path would be affected. Sketch and label this flight path “air resistance path” and **label two differences** between this and the ideal path. (2)

b) If no air resistance is present, what **adjustment** could be made to maximise range if the ball lands at the same vertical height as launch height and the launch speed is fixed? Draw and label this path “maximum range path” (2)

45° higher, longer

c) Explain how the magnitude of the force from air resistance acting in the horizontal changes as the projectile follows its flight path. (1)

Fair resistance is proportional to speed of projectile so as projectile slows in horizontal, so does Fair resistance

3. A golf ball is driven horizontally over the edge of platform at a speed of 21.0 m s^{-1}. The ground lies 16.8 m vertically below the launch position.

$U_{vertical} = 0$

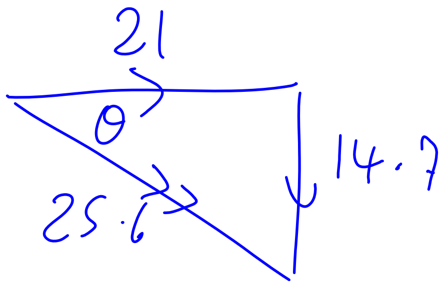
a. Calculate the **velocity** (magnitude and direction) of the ball after 1.50 seconds of flight. (4)

$u_h = 21.0$ right $\quad u_v = 0 \quad a_v = -9.8$

$v_v = u_v + at$

$v_v = 0 - (9.8 \times 1.5)$

$v_v = -14.7$ m/s (down)



$V = \sqrt{21^2 + 14.7^2}$

$V = 25.6$ m/s

$\theta = \tan^{-1}\left(\frac{14.7}{21}\right) = 35.0°$ angle of descent

b. Calculate the time it takes for the ball to reach ground level. (2)

$s_v = -16.8$ m (down)

$s_v = u_v t + \frac{1}{2} a t^2$

$-16.8 = 0 - 4.9 \cdot t^2$

$t^2 = \frac{16.8}{4.9} \Rightarrow t = 1.85$ s

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

$v^2 = 2 \times -9.8 \times -16.8$

$v^2 = 329.28$

$v = -18.14$ m/s (down)

$t = \frac{v-u}{a} = \frac{-18.14}{9.8}$

$t = 1.85$ s

c. Calculate the horizontal range of the ball. (1)

$s_h = u_h \times t_f = 21 \times 1.85164$

$s_h = 38.9$ m

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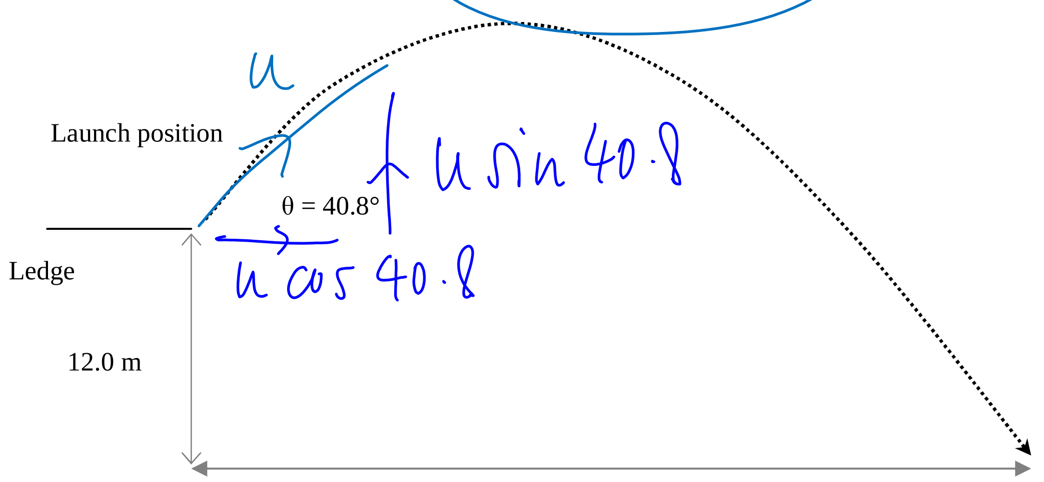
4. A student fires a bottle rocket from a 12 m high ledge. The initial velocity u is at an angle of 40.8° to the horizontal. The time to reach maximum height is 1.10 s.



a) Demonstrate by calculation, from the data given in the question, that u = 16.5 m s^{-1} to 3 significant figures. (You MUST NOT use u = 16.5 m s^{-1} as a starting point in your response) (3)

$V_v = 0 \quad t_{max} = 1.10\ s \quad a = -9.8$

$V_v = u_v + at$

$0 = u.\sin 40.8 - (9.8 \times 1.1)$

$10.78 = u . \sin 40.8°$

$u = \frac{10.78}{\sin 40.8} = 16.5\ m/s$

b) Calculate the horizontal range of the bottle. (5)

$u_h = u.\cos\theta = 16.5 \times \cos 40.8° = +12.4887$ — A

$s_v = -12 \quad V_v = ? \quad a = -9.8 \quad t_f = ?$

$V_v^2 = u_v^2 + 2.a.s$

$V_v^2 = 10.78^2 + (-19.6 \times -12)$

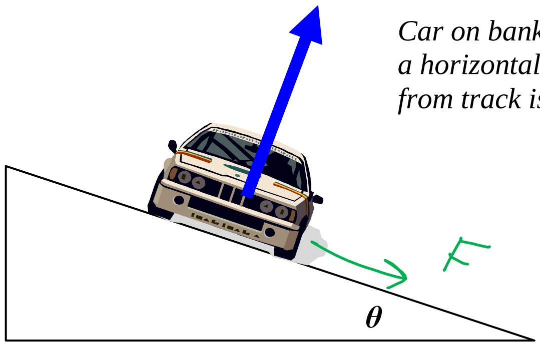
$V_v = \sqrt{351.4} = -18.745$ down (negative)

$t_f = \frac{v-u}{a} = \frac{-18.745 - 10.78}{-9.8}$

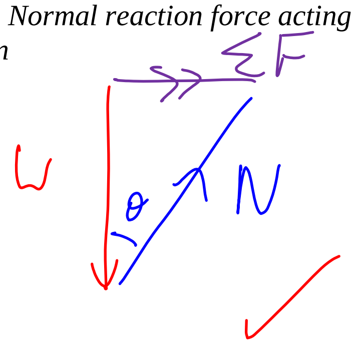
$t_f = 3.01\ s$ — B

range $= u_h \times t_f = 12.4887 \times 3.01 = \underline{37.6\ m}$

5. When a car is turning in a horizontal circle around a banked track, the normal reaction force from the bank acts perpendicular to the track as shown on the diagram below. No friction is required from the surface of the track to act sideways on the car if it enters the curve at the "design" speed.



Car on banked track viewed from the front whilst turning in a horizontal circle. Normal reaction force acting on car from track is shown



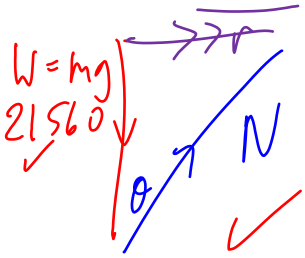
a) Explain, with the aid of a vector diagram in the space above, how the centripetal force is produced to keep the car at a fixed height on the track **and** enable the car to follow a horizontal circular path. (2)

ΣF Centripetal force is the resultant of adding weight and normal reaction.
Weight is balanced, net force acts to centre

b) For a car of mass 2200 kg calculate the magnitude of the normal reaction force required from the track to maintain a horizontal circular path of radius 200 m at a design speed of 90.0 km per hour. (4)

25 m/s

$\Sigma F = \frac{mv^2}{r} = \frac{2200 \times 25^2}{200} = 6875$

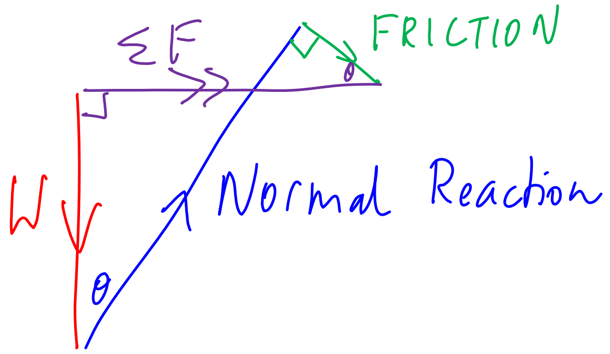


$N = (21560^2 + 6875^2)^{1/2}$

$N = 22629.6 = 2.26 \times 10^4 N$

diagram

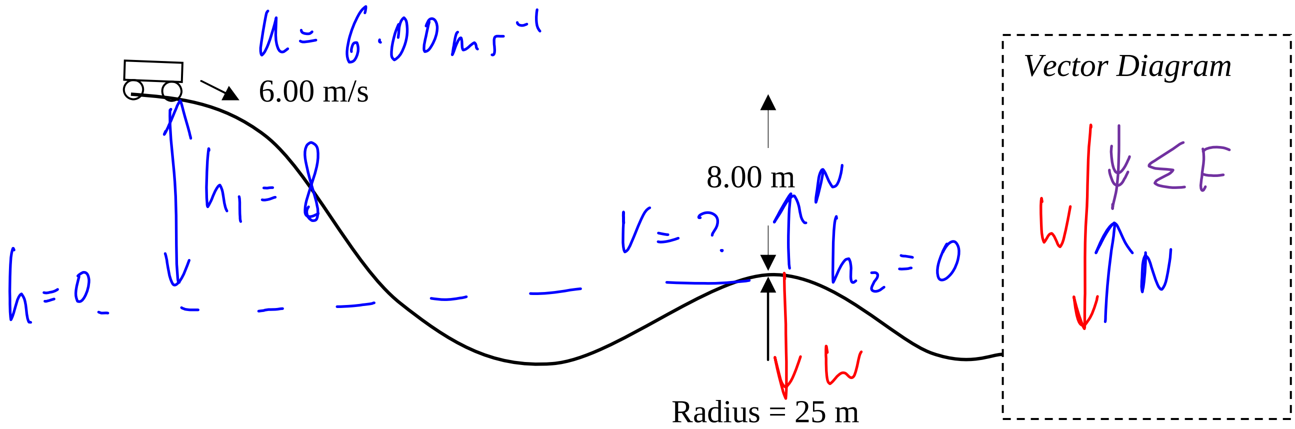
c) If the car goes around the track at a speed greater than the design speed then friction will act sideways on the car for it to maintain the same radius. Construct a vector diagram to show how the forces combine to give a centripetal force in this scenario. (your diagram must be reasonably accurate in showing vertical and horizontal lines) (2)



Correct orientation

θ + ⊥ ok

6. A roller coaster car has a mass of 470 kg and a speed of 6.00 m s^{-1} when at a height 8.00 m above the top of a hump. The car relies on mechanical energy only to go over the hump. The profile of the hump is part of a circle of radius of 25.0 m. *(ignore air resistance and friction)*



a) Use the principle of conservation of mechanical energy to demonstrate that the speed of the car at the top of the hump is 13.9 m s^{-1}.

(4)

$TME = KE + GPE = \text{Constant}$

$\frac{1}{2}\cancel{m}u^2 + \cancel{m}gh_1 = \frac{1}{2}\cancel{m}v^2 + \cancel{m}gh_2$ ✓

$(\frac{1}{2}6^2) + (9.8 \times 8) = \frac{1}{2} . V^2$ ✓ ✓

$96.4 = \frac{1}{2} V^2 \qquad (V^2 = 192.8)$

$V = 13.885 = 13.9 \text{ m/s}$

✓

b) On the diagram show the forces acting on the car at the top of the hump, then transfer these forces to a *vector diagram* that shows the sum of these forces (ΣF) in the space provided.

(2)

as above

free body ✓ vector ✓

c) Calculate the normal reaction force acting on the car at the top of the hump.

(3)

$\Sigma F = W - N$ (to centre = positive)

$\frac{mv^2}{r} = mg - N$ ✓

$N = mg - \frac{mv^2}{r}$

$N = (470 \times 9.8) - \frac{470 \times 192.8}{25}$ ✓

$N = 981.36 = 981\ N$ ✓ (up)

d) Describe and explain the sensation of weight of a rider at the top of the hump compared to their sensation when stationary on a flat surface.

(2)

Stationary sensation = mg (up) = 470×9.8

$N = 4606\ N$ (up) ✓

So lighter $(981 < 4606)$ ✓

approx 21%

e) If the speed at the top of the hump could be kept constant but the radius of the hump changed, explain what change would be required to decrease the sensation of apparent weight.

(1)

$N = mg - \frac{mv^2}{r}$

If $N \downarrow$, then $\frac{mv^2}{r}$ must $\uparrow$, so $r \downarrow$ ✓

radius must decrease

(must have explanation)

End of test