ALL SAINTS' COLLEGE

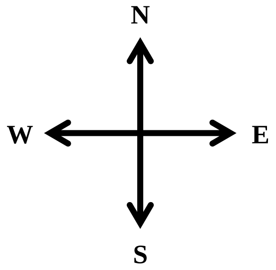
Ewing Avenue, Bull Creek, Western Australia

12 Physics ATAR Motion & Forces Test 1 February 2017

Time allowed: 50 minutes
Total marks available: 50
Show calculation answers to 3 significant figures

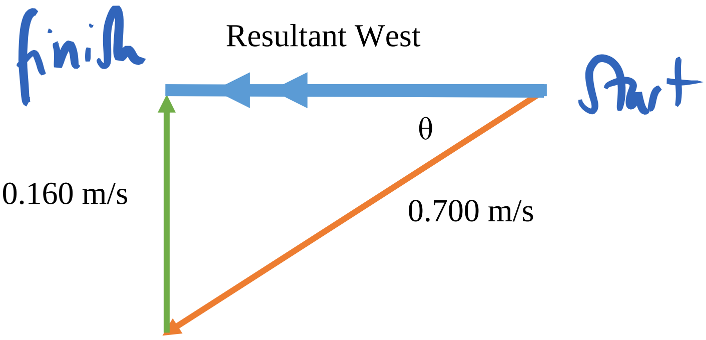
Student Name: ____**Solutions**

1. A bee is flying West at 0.700 m s^{-1} when it is hit by a wind acting North at 0.160 m s^{-1}



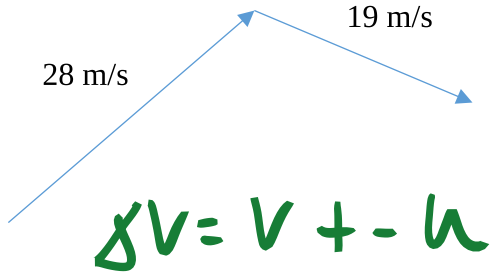
a) What direction should the bee point to maintain a resultant velocity in a direction due West? You must use a vector diagram in your answer.

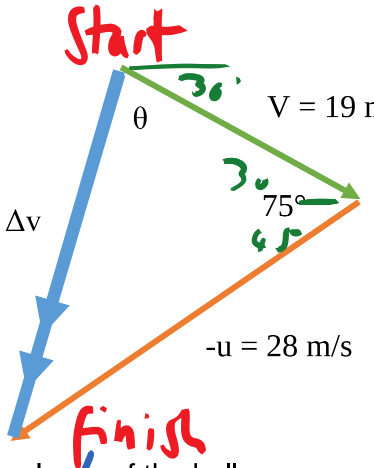
(3)



Description	Marks
Correct vector diagram	1
$\theta = \sin^{-1}$ (0.16 / 07) θ =13.2°	1
Direction = W 13.2° S	1
Total	**3**

2. A rubber ball is moving at 28 m s^{-1} in a direction N 45° E. It hits a wall and rebounds at 19 m s^{-1} in a direction E 30° S





a) Construct a vector diagram that shows the change in velocity of the ball.

(2)

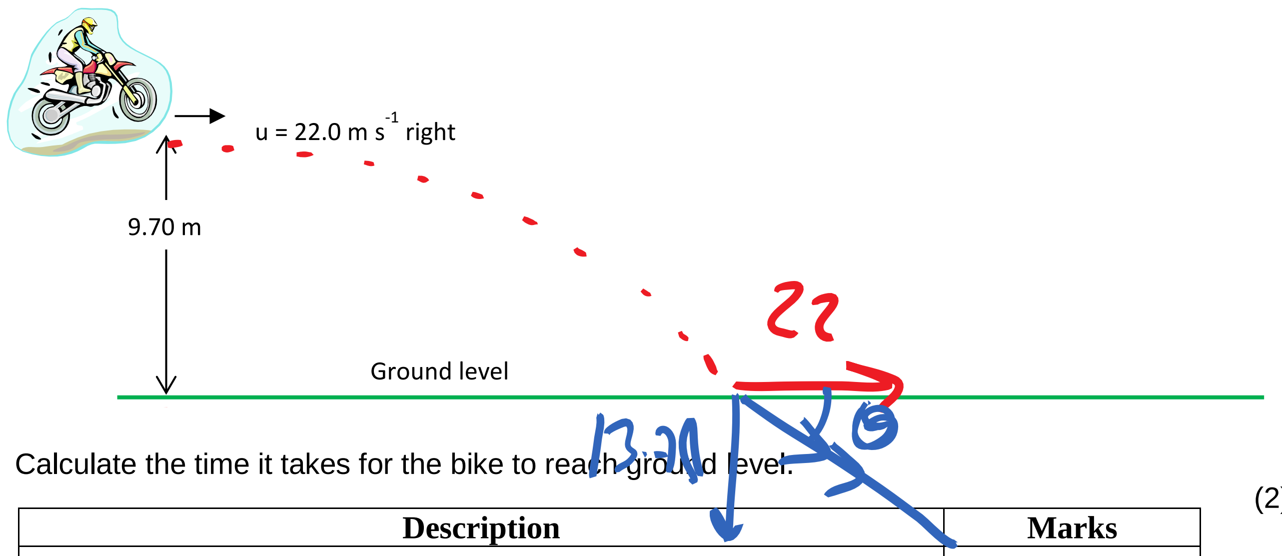
Description	Marks
Correct components head to tail	1
Correct resultant	1
Total	**2**

b) Calculate the change in velocity of the ball in this collision with the wall. You must state magnitude and direction in your solution.

(4)

Description	Marks
Use of cosine rule to calculate magnitude of Δv: $a^2 = b^2 + c^2 - 2bc \cos A$ $$\Delta v = \sqrt{19^2 + 28^2 - 2 \times 19 \times 28 \cos 75}$$	1
$$\Delta v = 29.489 = 29.5\ m\ s^{-1}$$	1
Sine rule to calculate angle $$\frac{a}{\sin A} = \frac{c}{\sin C}$$ $$\frac{29.489}{\sin 75} = \frac{28}{\sin \theta}$$ $$\theta = 66.51$$	1
Statement Δv = 29.5 m/s S 6.51° W	1
Total	**4**

3. A motocross stunt bike of mass 185 kg is driven horizontally over the edge of a jump at a speed of 22.0 m s^{-1}. The ground lies 9.70 m vertically below the launch position.



a. Calculate the time it takes for the bike to reach ground level. (2)

Description	Marks
s = ut + ½ at² (vertical) -9.7 = 0 -4.9t²	1
t = 1.40697 = 1.41 s	1
Total	**2**

b. Calculate the horizontal range of the bike. (1)

Description	Marks
Range = $u_h \times t_f$ = 22 x 1.40697 = 30.95 = 31.0 m	1
Total	**1**

c. Calculate the **velocity** (magnitude and direction) of the bike after as it arrives at ground level. (5)

Description	Marks
v = u + at (vertical) v = 0 -9.8 x 1.40697 v = -13.788 m/s (vertical)	1
v (overall) $v = \sqrt{22^2 + 13.788^2}$	1
v (overall) = 25.6963 = 26.0 m/s	1
Angle of descent = $\tan^{-1}$ (13.788/22)	1
Angle of descent = 32.1°	1
Total	**5**

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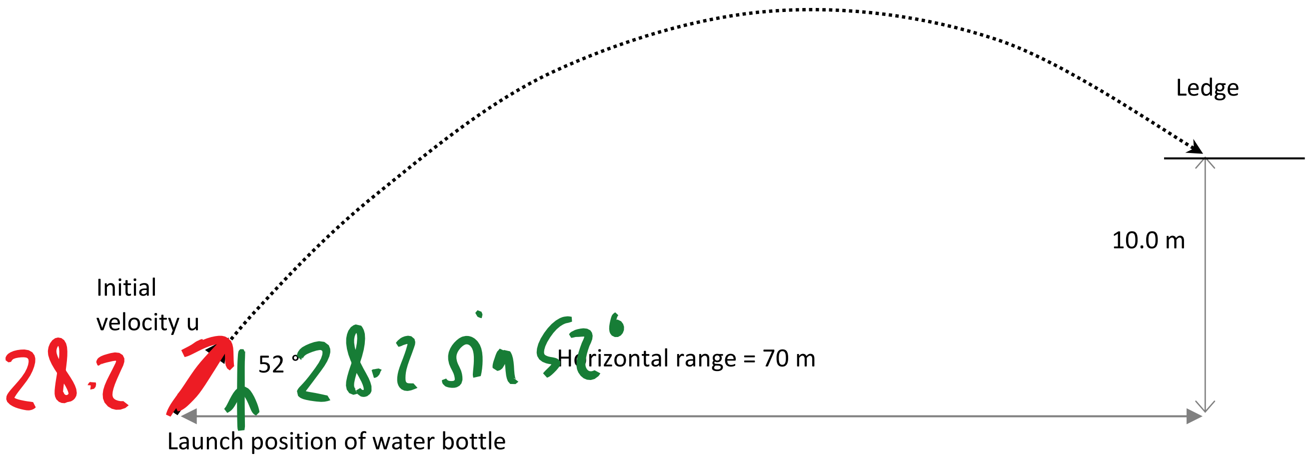
4. A student launches a projectile of mass 2.40 kg at an angle of 52° to the horizontal. He launches the projectile from a position 10.0 m below a ledge and it reaches the ledge after travelling a horizontal distance of 70 m.



a) Calculate the magnitude of the initial velocity u at an angle 52°. (5)

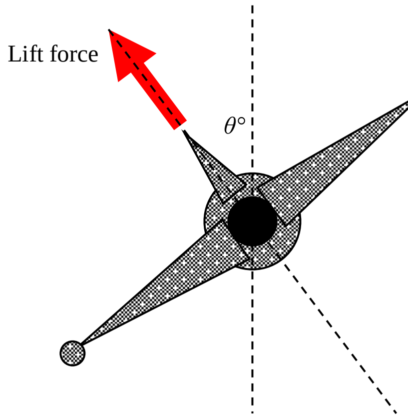
Description	Marks
$t_f = \frac{s_h}{u.\cos 52} = \frac{70}{u.\cos 52}$	1
$s_v = u_v t_f + \frac{1}{2}a(t_f)^2$ $+10 = u.sin52.t_f - 4.9(t_f)^2$	1
$+10 = u.sin52.\frac{70}{u.\cos 52} - 4.9\left[\frac{70}{u.\cos 52}\right]^2$ $+10 = 89.5959 - \left[\frac{63344.396}{u^2}\right]$	1
$\left[\frac{63344.396}{u^2}\right] = 89.5959 - 10$ $63344.396 = 79.5959.u^2$	1
$u^2 = 795.82$ $u = 28.21 = 28.2\ m\ s^{-1}$	1
Total	**5**

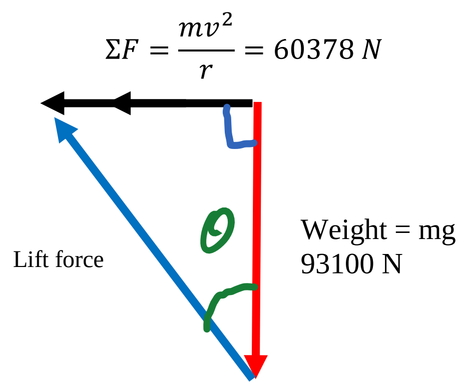
b) Calculate the maximum height above the launch position reached by the projectile. If you could not solve for part a) use a value of 28.2 m s^{-1} (3)

vertical

Description	Marks
$v^2 = u^2 + 2as$ $0 = (28.2 \times sin52)^2 - 19.6 \times s$	1-2
$s = +25.2\ m$	1
Total	**3**

5. When an aircraft is turning in flight it tilts its wings from the horizontal. The lift force from the wings acts perpendicular to the wings as shown on the diagram below.





a) Explain how the lift force can keep the aircraft at a fixed altitude **and** enable the aircraft to follow a horizontal circular path.

(2)

Description	Marks
Lift force has 2 components Vertical component balances the weight to keep a fixed height	1
Horizontal component is unbalanced, acts towards centre of circle to provide centripetal force	1
Total	**2**

b) For an aircraft of mass 9500 kg calculate the magnitude of lift force required from the wings to maintain a horizontal circular path of radius 1.42 km at a speed of 342 km per hour.

(4)

Description	Marks
r = 1420 m W = mg = 9500 x 9.8 = 93100 N v = 342/3.6 = 95 m s^{-1}	1
$\Sigma F = \frac{mv^2}{r} = \frac{9500 \times 95^2}{1420} = 60378.521\ N$	1
$Lift = \sqrt{93100^2 + 60378.521^2}$	1
Lift = 110964.75 = 1.11 x 10^5 N	1
Total	**4**

c) Calculate the angle (θ) from the vertical that that the aircraft must lean in order to achieve this motion.

(2)

Description	Marks
Angle of lean = $\tan^{-1}$ (60378.521/93100)	1
θ = 32.9647 = 33.0°	1
Total	**2**

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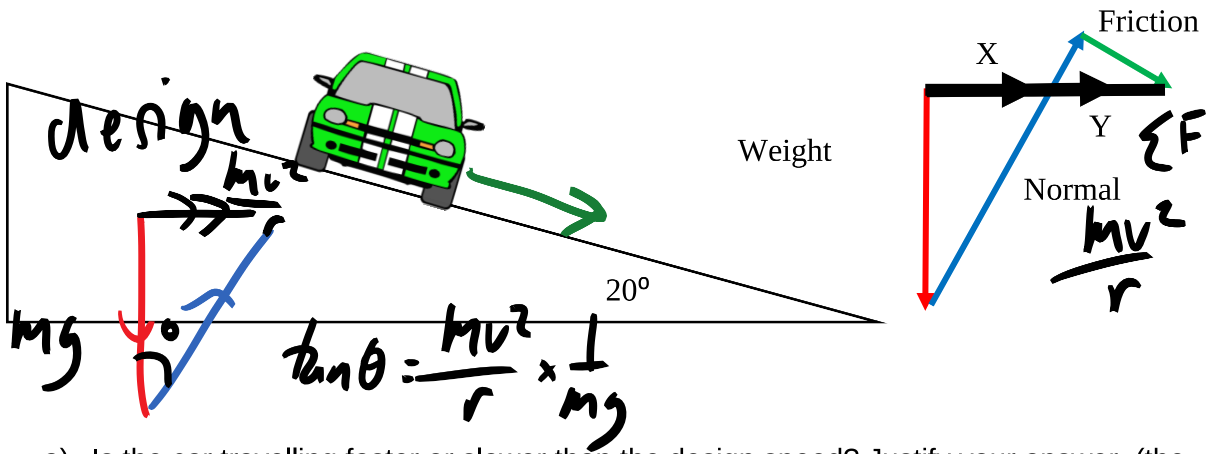
6. A car of mass 2000 kg is in horizontal circular motion on a banked track. The car has a speed of 12.0 m s^{-1} and is relying on friction to stay at a fixed height on the banked track. The radius of the circle is 30.0 m. The track is banked at an angle of 20.0^0 to the horizontal.



a) Is the car travelling faster or slower than the design speed? Justify your answer. (the design speed is the speed which has no reliance on friction)

(3)

Description	Marks
$v = \sqrt{gr \times tan\theta} = \sqrt{9.8 \times 30 \times tan20} = 10.34\ m\ s$	1-2
Therefore faster than design speed	1
Total	**3**

b) Construct a vector diagram to show the forces acting on the car.

(2)

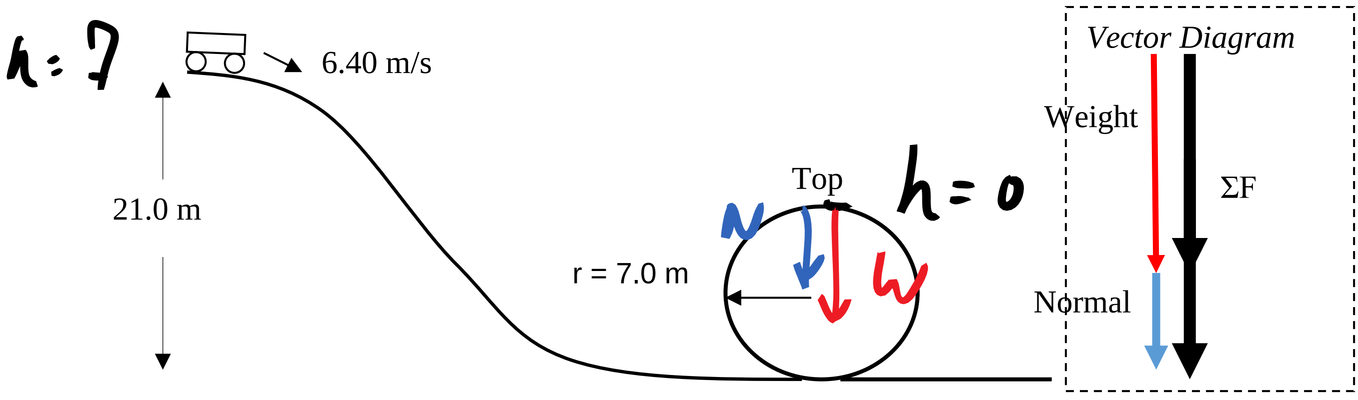
Description	Marks
Head to tail to show sum of forces acting to centre	1
Friction parallel to slope	1
Total	**2**

c) Calculate the magnitude of friction acting on the car from the banked surface.

(4)

Description	Marks
r = 30 m W = mg = 2000 x 9.8 = 19600 N v = 12 m s^{-1} $\frac{mv^2}{r} = X + Y$	
$\Sigma F = \frac{mv^2}{r} = \frac{2000 \times 12^2}{30} = 9600N$	1
$X = mg \times \tan 20 = 2000 \times 9.8 \times \tan 20$ $X = 7133.816592$	1
$Y = \frac{mv^2}{r} - X = 9600 - 7133.816592$ $Y = 2466.1834$	1
Friction $= Y \times \cos 20 = 2466.1834 \times \cos 20$ Friction = 2317.45 = 2.32×10^3 N	1
Total	**4**

7. A roller coaster car has a mass of 670 kg and starts from a height of 21.0 m above the ground. The car relies on mechanical energy only to go around the loop. The bottom of the circular loop is at ground level and the loop has a radius of 7.0 m. The car is moving at a speed of 6.40 m s^{-1} at the start height. *(ignore air resistance and friction in this question)*



a) Use the principle of conservation of mechanical energy to demonstrate that the speed of the car at the top of the loop is 13.3 m s^{-1}. (4)

Description	Marks
TME is constant so, $\frac{1}{2}mu^2 + mgh_1 = \frac{1}{2}mv^2 + mgh_2$ Use top of loop as reference height $\frac{1}{2}u^2 + gh_1 = \frac{1}{2}v^2 + gh_2$ substitute correct values both sides $\frac{1}{2}6.4^2 + 9.8 \times 7 = \frac{1}{2}v^2$	1-2
$89.08 = \frac{1}{2}v^2$	1
$v = \sqrt{178.16} = 13.3\ m\ s^{-1}$	1
Total	**4**

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

(1)

Description	Marks
Head to tail to show sum of forces acting to centre	1
Total	

Continued on next page

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

(3)

Description	Marks
r = 7 m m = 670 kg v = 13.3 m s^{-1}	
$$\Sigma F = \frac{mv^2}{r} = N + mg$$ (concept from diagram or equation)	1
$$N = \frac{mv^2}{r} - mg = \frac{670 \times 13.3^2}{7} - 670 \times 9.8$$	1
N = 10364.9 = 1.04 x 10^4 N	1
Total	**3**

End of test