Holy Cross College
Life to the Full

Western Australian Certificate of Education
ATAR course examination, 2018

Question/Answer Booklet

12 PHYSICS

Name SOLUTIONS

Test 2 - Motion and Gravitation

Student Number: In figures

Mark: $\frac{\quad}{38}$

In words ______________________

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Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: fifty-five minutes

Materials required/recommended for this paper

To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens, (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Short Answers	5	5	-	19	50
Section Two: Problem-solving	2	2	-	19	50
Section Three: Comprehension	-	-	-	-	-
				Total	100

Instructions to candidates

1. The rules for the conduct of examinations at Holy Cross College are detailed in the College Examination Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

3. Working or reasoning should be clearly shown when calculating or estimating answers.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

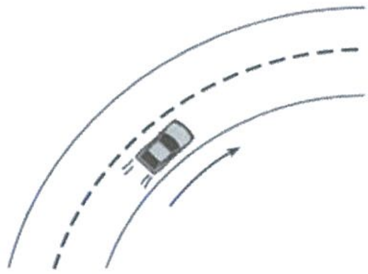
6. Answers to questions involving calculations should be ***evaluated and given in decimal form.*** It is suggested that you quote all answers to ***three significant figures***, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are ***clearly and legibly set out***.

7. Questions containing the instruction "estimate" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained. Give final answers to a maximum of two significant figures and include appropriate units where applicable.

8. Note that when an answer is a vector quantity, it must be given with magnitude and direction.

9. In all calculations, units must be consistent throughout your working.

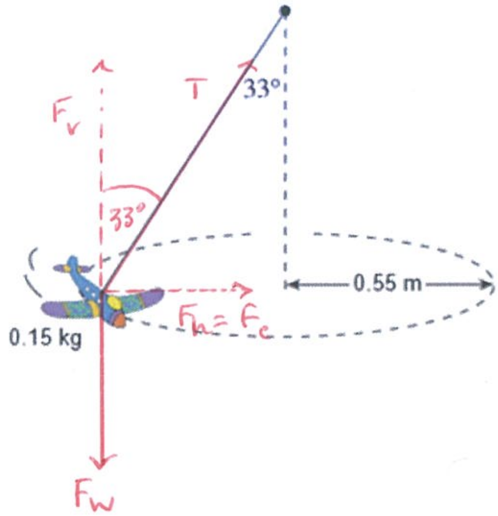
1. A car is moving at a constant speed around a flat circular track. Which of the following options (A, B, C or D) best describes the velocity, acceleration and net force acting on the car? (Circle your answer.) [1 mark]

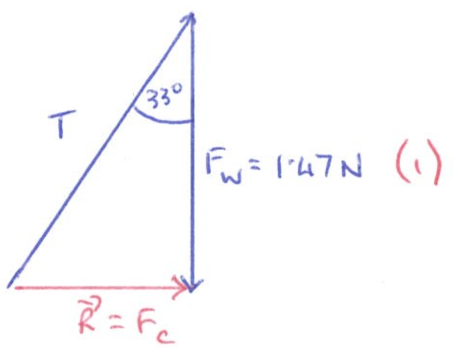


	VELOCITY OF CAR	ACCELERATION OF CAR	NET FORCE ON CAR
A.	↗	↗	↖
B.	↗	↘	↖
(1) C.	↗	↘	↘
D.	↘	↘	↘

2. A 0.150 kg toy airplane is suspended on a string and is travelling in a horizontal circle at a constant speed as shown in the diagram to the right.

(a) What is its centripetal force? [4 marks]





$$\tan 33.0^\circ = \frac{F_c}{1.47} \quad (1)$$

$$\Rightarrow \underline{F_c = 0.955 \text{ N} \quad \text{towards the centre}}$$

(1) (1)

(b) What is the period of its motion? [5 marks]

$$F_c = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2} \quad (2)$$

$$\Rightarrow \quad T = \sqrt{\frac{4\pi^2 mr}{F_c}} \quad (1)$$

$$= \sqrt{\frac{4\pi^2 (0.150)(0.550)}{0.955}} \quad (1)$$

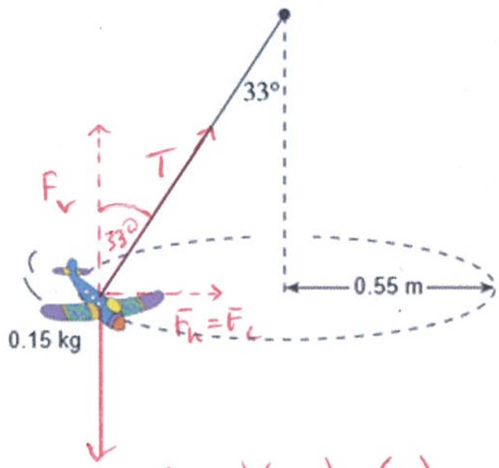
$$= \underline{1.85\text{ s}} \quad (1)$$

(c) Calculate the tension in the rope when the toy airplane is flying on the ***Moon*** in exactly the same pattern as shown in the diagram in part (a). [4 marks]

$$\Sigma F_v = 0$$

$$\Rightarrow \quad T\cos 33.0^\circ = 0.243 \quad (1)$$

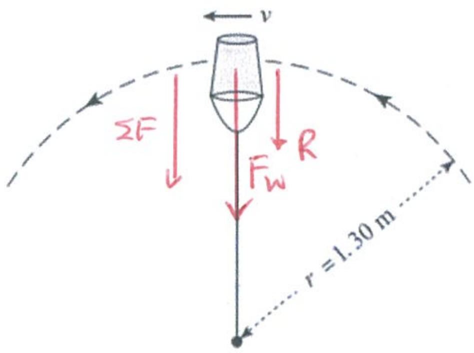
$$\Rightarrow \quad \underline{T = 0.290\text{ N}} \quad (1)$$



$$F_W = (0.150)(1.62) \quad (1)$$

$$= 0.243\text{ N} \quad (1)$$

3. A physics student swings a 0.500 kg pail of water in a vertical circle of radius 1.30 m as shown in the diagram to the right.



(a) What is the minimum speed (v_{min}) at the top of the circle if the water is not to spill from the pail?

[3 marks]

$\Sigma F = F_c = F_w + R$

If $R=0$: $F_c = F_w$

$\Rightarrow \frac{\cancel{m}v^2}{r} = \cancel{m}g$ (1)

$\Rightarrow v = \sqrt{gr}$

$= \sqrt{(9.80)(1.30)}$ (1)

$= \underline{3.57\ ms^{-1}}$ (1)

(b) If the velocity increases so that the bottom of the pail exerts a normal force of 2.45 N on the water when it is on the top of the swing, what is the pail's new velocity?

[4 marks]

$\Sigma F = F_c = F_w + R$ (1)

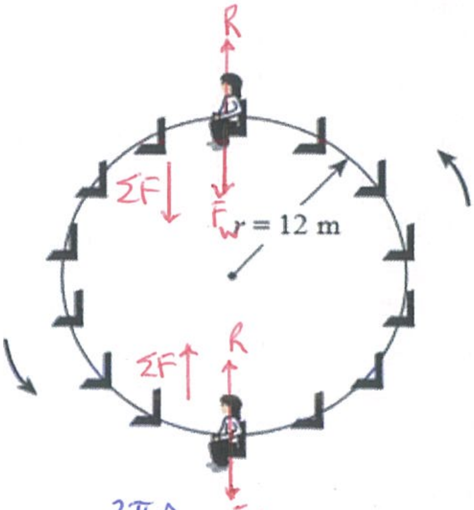
$\Rightarrow \frac{mv^2}{r} = mg + R$ (1)

$\Rightarrow \frac{(0.500)(v^2)}{(1.30)} = (0.500)(9.80) + 2.45$ (1)

$\Rightarrow$ $\underline{v = 4.37\ ms^{-1}\ \text{horizontal}}$ (1)

4. The diagram to the right shows a 52.0 kg child riding on a Ferris wheel of radius 12.0 m and period 18.0 s.

(a) What is the apparent weight of the child at the top of the ride? [5 marks]



$$\Sigma F = F_c = F_w - R$$

$$\Rightarrow \quad R = F_w - F_c \quad (1)$$

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

$$= (52.0)\left[9.80 - \frac{(4.19)^2}{12.0}\right] \quad (1)$$

$$= \underline{4.33 \times 10^2 \text{ N}} \quad (1)$$

$$v = \frac{2\pi r}{T}$$

$$= \frac{2\pi(12.0)}{(18.0)} \quad (1)$$

$$= 4.19 \text{ ms}^{-1} \quad (1)$$

(b) What is the apparent weight of the child at the bottom of the ride? [4 marks]

$$\Sigma F = F_c = R - F_w \quad (1)$$

$$\Rightarrow \quad R = F_c + F_w \quad (1)$$

$$= \frac{mv^2}{r} + mg$$

$$= (52.0)\left[\frac{(4.19)^2}{12.0} + 9.80\right] \quad (1)$$

$$= \underline{5.86 \times 10^2 \text{ N}} \quad (1)$$

5. A bicycle and its rider have a total mass of 85.0 kg and travel around a circular banked track at a radius of 20.0 m and at a constant speed of 10.0 ms^{-1}, as shown in Figure 1 below. The track is banked and there is no sideways friction force applied by the track on the wheels.

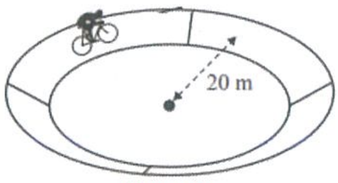


Figure 1

(a) Draw on the diagram below the forces acting on the bicycle. Make sure to label your force vectors. Do not show any nett or component forces. [2 marks]

R should be bigger than F_W.

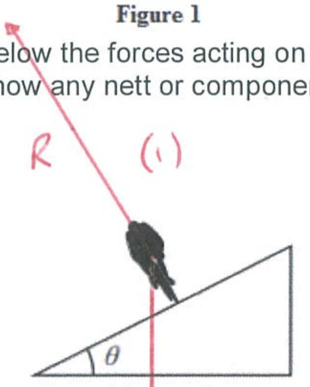
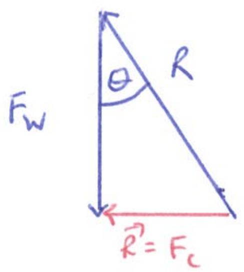


Figure 2

(b) Calculate the correct angle of the bank needed for the riders to travel at 10.0 ms^{-1} at a radius of 20.0 m, if we assume friction is not contributing to the centripetal force. [4 marks]



$$\tan\theta = \frac{F_c}{F_W} \quad (1)$$

$$= \frac{\cancel{m}v^2}{r} \times \frac{1}{\cancel{m}g} \quad (1)$$

$$= \frac{(10.0)^2}{(20.0)(9.80)} \quad (1)$$

$$\Rightarrow \underline{\theta = 27.0^\circ \text{ to the horizontal}} \quad (1)$$

6. Explain the difference between apparent weightlessness and zero gravity, giving examples where each could occur. [4 marks]

APPARENT WEIGHTLESSNESS

- Reaction force experienced is zero. (1)

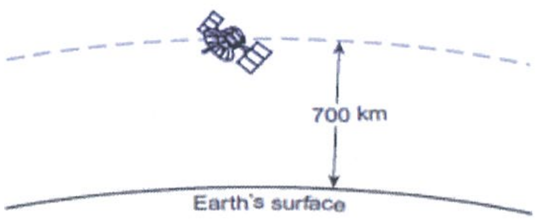
  e.g. Orbiting space station accelerates towards the centre of the earth at the same rate as the occupants. (1)

ZERO GRAVITY

- The nett force due to gravity is zero. (1)

  e.g. Centre of the Earth; point between the Earth and Moon where $F_{Earth} = F_{Moon}$. (1)

7. An 8.87×10^4 kg satellite is orbiting the Earth at an altitude of 7.00×10^2 km. Assume the satellite is in a stable orbit.



What is the orbital speed of this satellite? [4 marks]

$$F_g = F_c$$

$$\Rightarrow \frac{G M_E \cancel{m_s}}{r^{\cancel{2}}} = \frac{\cancel{m_s} v^2}{\cancel{r}}$$

$$\Rightarrow v = \sqrt{\frac{G M_E}{r}} \quad (1)$$

$$= \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.37 \times 10^6 + 7.00 \times 10^5)}} \quad (1) \leftarrow (1)$$

$$= \underline{7.50 \times 10^3 \ ms^{-1}} \quad (1)$$

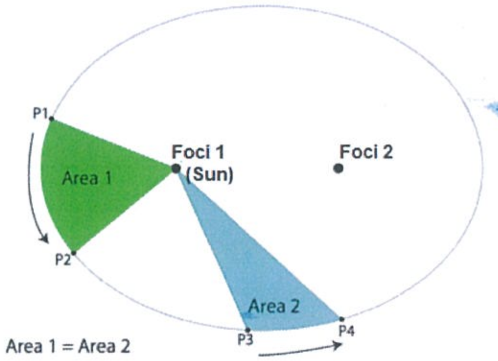
8. (a) Derive Kepler's third law. Your derivation must start with two forces. [3 marks]

$$F_g = F_c \quad (1)$$

$$\Rightarrow \frac{GM_S m_E}{r^2} = \frac{m_E v^2}{r} = \frac{4\pi^2 m_E r}{T^2} \quad (1)$$

$$\Rightarrow r^3 = \frac{GM_S T^2}{4\pi^2} \quad (1)$$

Use the diagram below to answer parts (b) and (c) of this question. Please note the area sectors labelled Area 1 and 2 are equal areas. Use Kepler's Laws to answer the questions below about this diagram.



(b) Compare the velocity of the object as it moves from P1 to P2 versus when it moves from P3 to P4. Explain why the velocities are different or similar. [2 marks]

$P_1 \rightarrow P_2$: velocity is faster. (1)

- Since $v = \sqrt{\frac{GM_S}{r}}$ and r is smaller, v must be bigger. (1)

(c) Compare the time taken for the object to move from P1 to P2 versus the time to move from P3 to P4. State which of Kepler's Laws you applied to answer this question. [2 marks]

- Time taken for both sectors is the same. (1)
- Kepler's Second Law. (1)

9. If the period of a satellite orbiting the Earth is 36.0 hours, what is the orbital radius (radial distance from the centre of the Earth) for this satellite? [4 marks]

$$r^3 = \frac{G M_E T^2}{4\pi^2} \quad (1)$$

$$= \frac{(6.67\times10^{-11})(5.97\times10^{24})(36.0\times3.60\times10^3)^2}{4\pi^2} \quad (1)\ (1)$$

$$\Rightarrow \quad \underline{r = 5.53\times10^7\ \text{m}} \quad (1)$$