HOLY CROSS COLLEGE

Life to the Full

Western Australian Certificate of Education
ATAR course examination, 2019

Question/Answer Booklet

12 PHYSICS

Name SOLUTIONS

Test 2 – Gravitation & Equilibrium

Student Number: In figures | | | | | | | | |

Mark: 42

In words _____

_____

Time allowed for this paper

Reading time before commencing work: five minutes
Working time for paper: sixty 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	-	-	-	-	-
Section Two: Problem-solving	8	8	60	43	100
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(is) 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. The Hubble Space Telescope (mass 1.16×10^4 kg) orbits the earth in a circular orbit 6.10×10^2 km above the surface of the earth.

(a) Calculate the gravitational force of attraction between the earth and the telescope. (3 marks)

$$F = \frac{GM_E M_S}{r^2}$$

$$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(1.16\times10^{4})}{(6.37\times10^{6} + 6.10\times10^{5})^2} \quad (1)$$

(1)

$$= 9.50\times10^{4}\ \text{N} \quad (1)$$

(b) Calculate the period (T) of the space telescope about Earth. (3 marks)

$$r^3 = \frac{GM_E T^2}{4\pi^2}$$

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

$$= \sqrt{\frac{4\pi^2 (6.37\times10^{6} + 6.10\times10^{5})^3}{(6.67\times10^{-11})(5.97\times10^{24})}} \quad (1)$$

$$= 5.81\times10^{3}\ \text{s} \quad (1)$$

2. Given that the period of orbit of the moon is 27.3 days, determine the period of the International Space Station, which has a mass of 7.50 tonne, given that the radius of its orbit is 10.0% (0.100) of the Earth-Moon radius.

(4 marks)

$$r_M^3 = \frac{GM_E T_M^2}{4\pi^2}$$

$$\Rightarrow T_M = \sqrt{\frac{4\pi^2 r_M^3}{GM_E}} = 27.3 \text{ days} \quad (1)$$

$$T_{station} = \sqrt{\frac{4\pi^2 (0.100\, r_M)^3}{GM_E}} \quad (1)$$

$$= \sqrt{(0.100)^3}\ \sqrt{\frac{4\pi^2 r_M^3}{GM_E}}$$

$$= (3.162\times10^{-2})(27.3) \quad (1)$$

$$= 0.863 \text{ days}$$

$$= 7.46\times10^4 \text{ s}$$

} Either (1)

3. Deimos is a small moon that orbits Mars. It has a mass of 1.48×10^{15} kg and orbits at a mean distance of 2.35×10^7 m from the centre of the planet. Its period of orbit is 30.3 hours.

(a) Use this information to determine the mass of the planet Mars.

(3 marks)

$$r^3 = \frac{GM_M T^2}{4\pi^2}$$

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

$$= \frac{4\pi^2 (2.35\times10^7)^3}{(6.67\times10^{-11})(30.3\times3.60\times10^3)^2} \quad (1)$$

$$= 6.46\times10^{23} \text{ kg} \quad (1)$$

(b) The Mars Survey Orbiter was placed in a stable orbit above Mars during a NASA mission. It was given a period of revolution of 135 minutes. Given the radius of Mars is 3.39×10^6 m, determine the height of the orbiter above the surface of the planet.

(3 marks)

$$r^3 = \frac{GM_M T^2}{4\pi^2}$$

$$\Rightarrow \quad r = \sqrt[3]{\frac{(6.67\times10^{-11})(6.46\times10^{23})(135\times60.0)^2}{4\pi^2}} \quad (1)$$

$$= 4.15\times10^6 \text{ m} \quad (1)$$

$$r = r_M + h$$

$$\Rightarrow \quad h = 4.15\times10^6 - 3.39\times10^6$$

$$= \underline{7.60\times10^5 \text{ m}} \quad (1)$$

(c) What would be the acceleration due to gravity on the surface of Mars?

(3 marks)

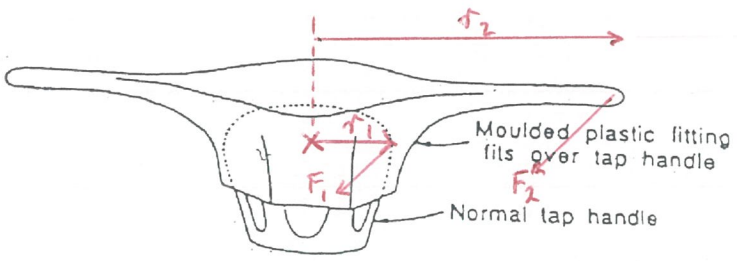
$$g = \frac{GM_M}{r_M^2} \quad (1)$$

$$= \frac{(6.67\times10^{-11})(6.46\times10^{23})}{(3.39\times10^6)^2} \quad (1)$$

$$= \underline{3.75 \text{ ms}^{-2}} \quad (1)$$

4. People with severe arthritis in their hands often have difficulty turning taps on and off. A tap-making company has recognised this and developed a device that fits over the tap and has two arms as shown in the diagram below. Explain the principle upon which this works.

(3 marks)



- The turning effect M is given by: $M = F_1 r_1 = F_2 r_2$. (1)
- The force F_2 needed to turn the device is less than F_1. (1)
- $F_2 = \frac{F_1 r_1}{r_2}$ As $r_2 > r_1$, $F_2 < F_1$ (1)

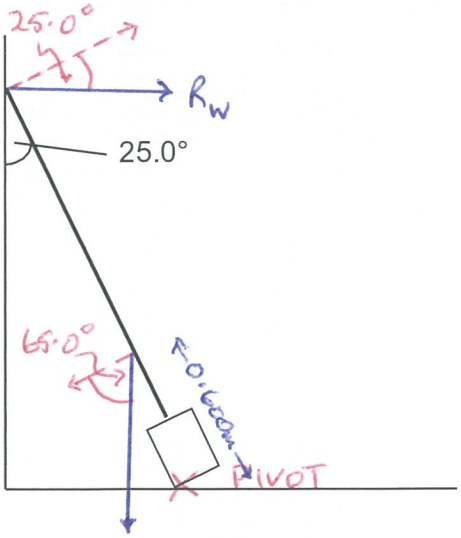
Key marking points: M is the same for the tap and device

$r_2 > r_1 \Rightarrow F_2 < F_1$

∴ Easier to turn.

5. A long-handled shovel 1.80 m long is leaning against a smooth wall in the Maintenance Shed. It has a mass of 3.50 kg and its centre of mass is 60.0 cm from the bottom. Assuming the handle and shovel forms a straight line, calculate the reaction force exerted by the wall if the handle is 25.0° to the wall.

(4 marks)



$F = (3.50)(9.80)$

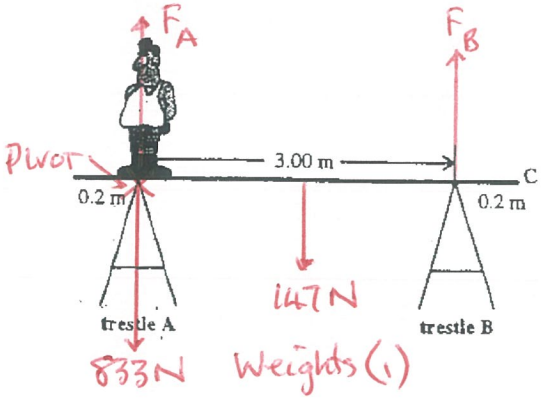
$= 34.3\,N$ (1)

$\Sigma CM = \Sigma ACM$ ✓ Correct components (1)

$\Rightarrow (R_W \cos 25.0°)(1.80) = (34.3 \cos 65.0°)(0.600)$ (1)

$\Rightarrow$ $R_W = 5.33$ N away from the wall. (1)

6. An 85.0 kg painter is standing on a plank, which rests on two trestles, while painting the upper section of a wall. Assume that the plank is uniform and has a mass of 15.0 kg.



Calculate the forces exerted by each trestle on the plank if the painter stands at trestle A.

(5 marks)

Take A as pivot.

$\Sigma CM = \Sigma ACM$

$\Rightarrow (147)(1.50) = F_B(3.00)$ (1)

$\Rightarrow F_B = 73.5\ N\ up$ (1)

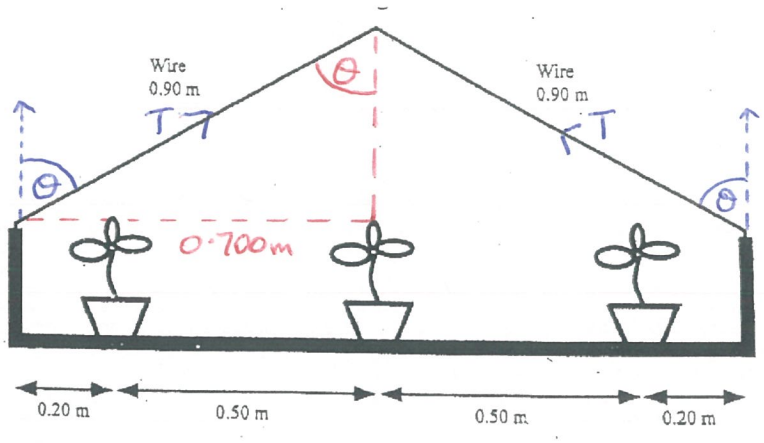
$\Sigma F_V = 0$

$\Rightarrow F_A + F_B = 833 + 147$ (1)

$\Rightarrow F_A = 980 - 73.5$

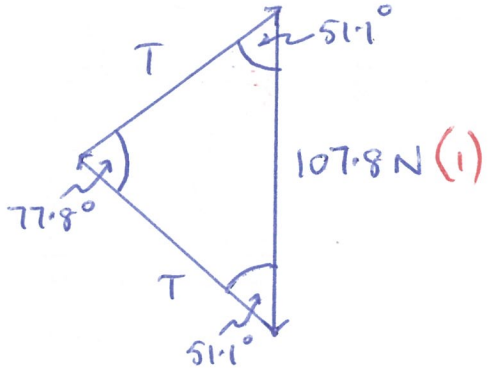
$= 907\ N\ up$ (1)

7. You are designing a pot plant shelf that can hang from a single point. The shelf has a mass of 3.50 kg and is 1.40 m in length and you allow for three plants with masses no more than 2.50 kg each. Determine the tension in each of the cables. (4 marks)



$\sin\theta = \frac{0.700}{0.900}$

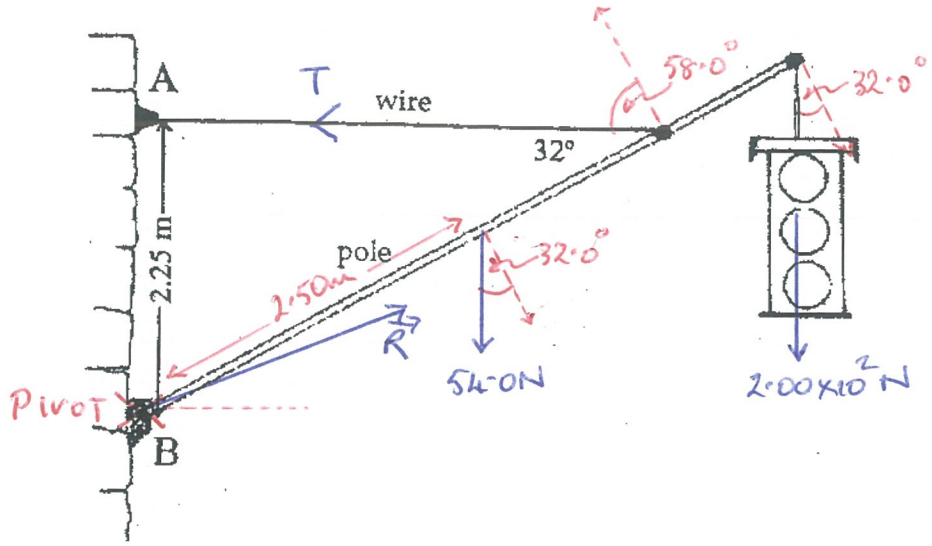
$\Rightarrow \theta = 51.1^\circ$



$\frac{T}{\sin 51.1^\circ} = \frac{107.8}{\sin 77.8^\circ}$

$\Rightarrow T = 85.8\ N$

8. The diagram below shows how a set of traffic lights can be suspended from a building at the side of a road. Copper wire holds the 5.00 m long uniform rigid pole in place. The wire is horizontal and attached to the wall at bracket A and the pole is attached to the wall at bracket B. The pole weighs 54.0 N and the traffic lights weigh 2.00×10^2 N. Other dimensions are shown in the diagram.



(a) Find the magnitude of the tension force that the wire exerts on the pole.

(4 marks)

Take B as pivot.

$\Sigma CM = \Sigma ACM$

$\Rightarrow (54.0 \cos 32.0^\circ)(2.50) + (2.00 \times 10^2 \cos 32.0^\circ)(5.00) = T(2.25)$ (1)

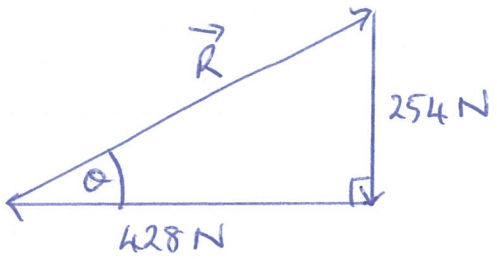
Correct components (1)

Correct distances (1)

$\Rightarrow T = 428\ N$ (1)

(b) Determine the reaction force exerted at bracket B by the wall onto the pole.

(3 marks)



$\vec{R} = \sqrt{(254)^2 + (428)^2}$

$= 498\ N$ (1)

$\tan\theta = \frac{254}{428}$

$\Rightarrow \theta = 30.7^\circ$ (1)

$\therefore$ $\vec{R} = 498\ N$ at 30.7° above the horizontal (1)