



# ALL SAINTS' COLLEGE

Ewing Avenue, Bull Creek, Western Australia

12 Physics ATAR Motion & Forces Test 2 March 2017

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

Student Name: \_\_\_\_\_

1. In June 2017 the European Space Agency will launch the satellite Sentinel-5P. It will go into a low earth Sun Synchronous Orbit (SSO) at an altitude of 824 km. It will be used to monitor air pollution. Determine the gravitational field strength of the Earth at this altitude.

(3)

2. Use equations on your data sheet that provide a conceptual basis to derive the following equation. You must explain how the concepts are linked. You may **not** start with the equation for Kepler's 3<sup>rd</sup> Law:

(3)

$$r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

3. Titan is one of 62 moons in orbit around the planet Saturn. Saturn has a mass of  $5.68 \times 10^{26}$  kg and a diameter of 116 464 km. The orbital radius of Titan is 1 221 870 km. The gravitational force of attraction between Titan and Saturn is  $3.42 \times 10^{21}$  N. From this information calculate the mass of Titan.

(3)

4. A satellite of mass 5 400 kg is in a circular orbit and moving with a speed of  $2.20 \text{ km s}^{-1}$  around the Earth's surface. Calculate the altitude of the satellite.

(3)

5. Artificial satellites orbiting the Earth are used for many applications including communication, navigation, remote-sensing and research.

a) Describe the **difference** between a Polar Orbit and an Equatorial Orbit and give **one advantage** of a Polar Orbit. You may sketch in the area below to aid your explanation.

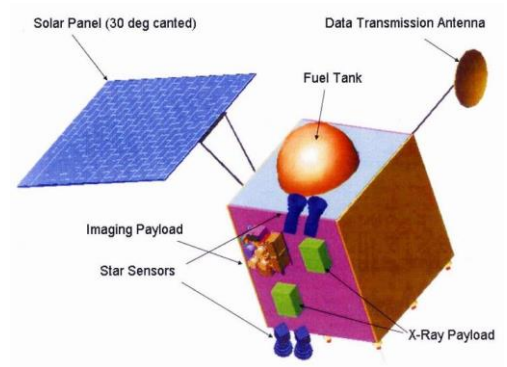
(2)



b) Give three specific features of a sun-synchronous orbit (SSO) that distinguish it from other orbit types.

(3)

6. In 2008 the Indian Space agency successfully put the satellite Chandrayaan-1 into a circular orbit around the moon. In 2009 all contact with the satellite was lost. In June 2016 NASA were able to locate the satellite again (they found it in exactly the same place where it was left in the first place!). The Chandrayaan-1 satellite is a cube of side length 1.70 m with a mass of 675 kg and it is orbiting at 200 km above the lunar surface.



- a) Determine the orbital period of Chandrayaan-1 from this data.

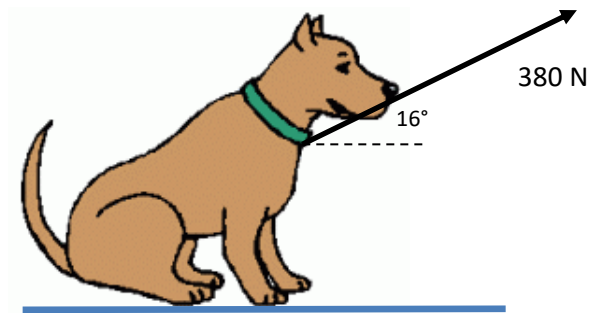
(4)

- b) Calculate the centripetal acceleration of Chandrayaan-1 relative to the Moon.

(3)

7. The dog in the picture is refusing to move and has become completely rigid. Her owner is pulling on the lead with a tension of 380 N acting at  $16^\circ$  to the horizontal. The dog has a mass of 44.0 kg.

- a. Calculate the force of friction acting on the dog from the floor to keep it in equilibrium.



(2)

- b. Calculate the total normal reaction force acting from the ground onto the dog

(2)

8. The photograph shows a Jar Opener that can be used by people who have a weak grip. This could be because of old age, a disability or an injury.

The right hand shown is gripping the Jar Opener. The left hand is holding a jar with a lid that is difficult to open.

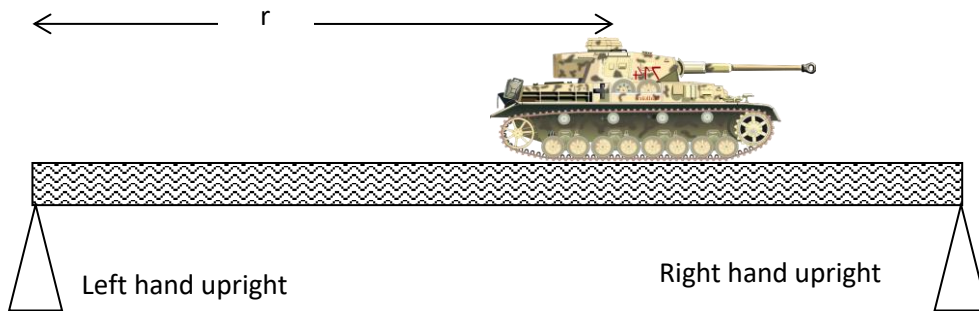
Explain the physics principles that allow this device to be effective for a person with a weak grip



(2)

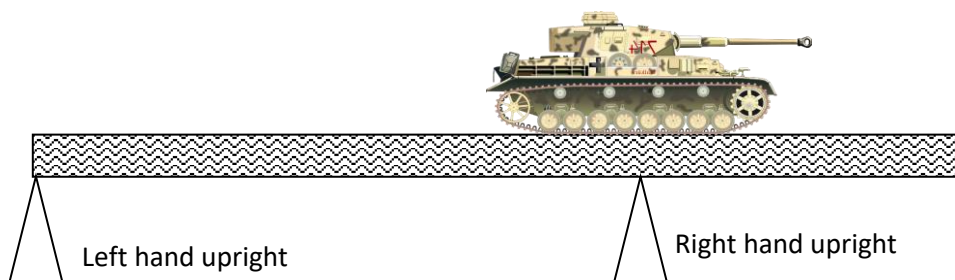
9. A 16 000 kg tank is crossing a 23.0 m long bridge supported at either end by vertical uprights. The bridge has a mass of 24 000 kg. The right hand upright is being compressed with a force of 230 kN.
- a. Calculate the distance  $r$ , that the centre of mass of the tank is placed from the left hand upright.

(3)

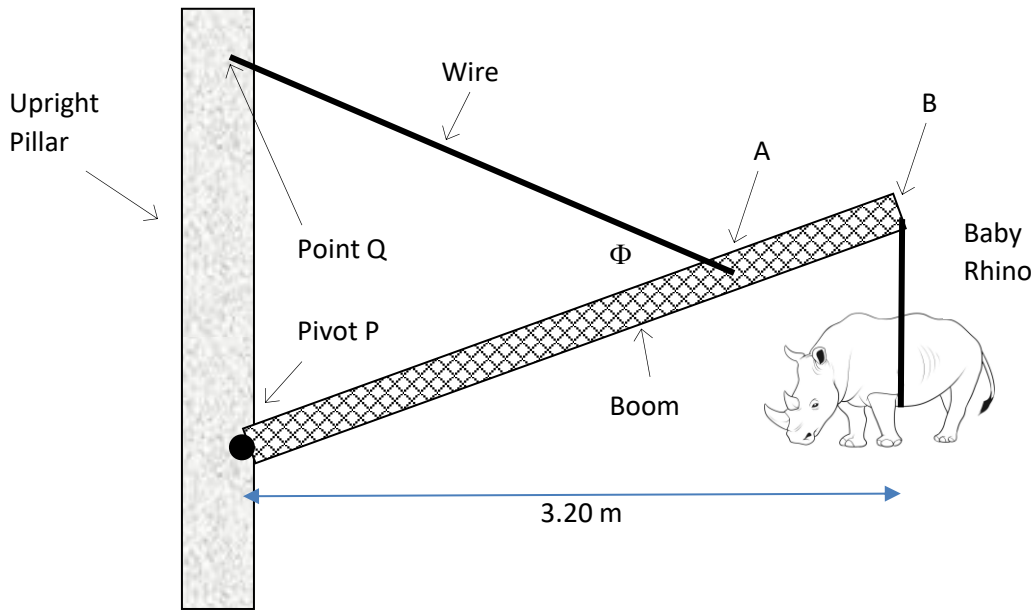


- b. The right hand upright is moved to the position shown. Describe any changes (in terms of magnitude and direction) to the forces acting through both the left hand and right hand uprights. Provide a brief explanation for each response. No calculation is required.

(3)



10. Consider the forces acting on the boom of a crane. The wire that lifts the crane connects between point Q on the upright pillar to the boom at point A. The boom pivots at point P. A baby rhinoceros of mass 270 kg is suspended from the boom at point B. The masses, dimensions and angles for this set up are shown in the following table.



Mass of boom	120 kg
Mass of Baby Rhino	270 kg
Angle $\phi$	$49.75^\circ$
Length of boom PB	3.40 m
Horizontal length from P to centre of mass of the Rhino	3.20 m
Length PA	2.60 m
Tension	?
Reaction force at P	?

- a) Calculate the **tension** in the wire between Q and A.

(4)

**FINAL QUESTION ON BACK PAGE**

Continued on next page

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- b) Calculate the magnitude and direction of the reaction force acting on the boom at the pivot P. If you could not solve for part a) or are unsure of your answer then use a tension value of 5215 N.

(5)

The boom is raised by shortening the length of wire between the upright pillar and location A. When this happens angle  $\Phi$  can change to become  $90^\circ$

- i. What happens to the magnitude of the tension T in this case? (*circle a response below*)

increases                      decreases                      stays the same                      not enough information given

(1)

- ii. Explain **why** this occurs.

(2)

- iii. **Explain** the likely change to the *direction* of the reaction force R as angle  $\Phi$  becomes  $90^\circ$

(2)