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CORPUS CHRISTI COLLEGE
SEQUERE DOMINUM

ATPHY 2018
Gravity Investigation 5.0%
Part (2) quiz

Student name: Soln

1. How many metres are there in one light year? **[3 marks]**

$1\,ly = 60 \times 60 \times 24 \times 365.25 \times (3 \times 10^8)$

$= 9.47 \times 10^{15}\ m.$

2. How close is Ross128b to our solar system? **[1 mark]**

11 LIGHT YEARS AWAY.

3. Briefly explain how Ross128b was discovered. **[2 marks]**

- ESO's HIGH ACCURACY RADIAL VELOCITY PLANET SEARCHER (HARPS).
- EXAMINATION OF MANY YEARS OF HARPS DATA.

4. Why is Ross128b of ~~much~~ such great interest to astronomers? **[2 marks]**

- EARTH-LIKE PLANET
- INSIDE HABITABLE ZONE (POSSIBLY).

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On 22 February 2017, astronomers announced that the planetary system of this star is composed of seven temperate terrestrial planets, of which five (b, c, e, f and g) are similar in size to Earth, and two (d and h) are intermediate in size between Mars and Earth. Three of the planets (e, f and g) orbit within the habitable zone.

5. What planetary system is this statement referring to? **[2 marks]**

THE SEVEN PLANETS THAT ORBIT AROUND THE STAR TRAPPIST-1.

6. What is meant by the term, 'habitable zone'? **[2 marks]**

THE RANGE OF ORBITS AROUND A STAR THAT CAN SUPPORT LIQUID WATER.

7. What type of stars do these planets orbit? **[2 marks]**

TRAPPIST-1 IS AN ULTRA COOL RED DWARF STAR.

8. What telescope will take the place of the Hubble Space Telescope and where will it be positioned? **[2 marks]**

- THE JAMES WEBB TELESCOPE.
- THE SECOND LAGRANGE (L2) POINT.

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Johannes Kepler brought the power of mathematics to bear on the observations of the solar system by his mentor Tycho Brahe. By 1619 Kepler had stated three laws:

i. Planets follow plane elliptical paths with the sun at one focus.

ii. A radial line between the sun and a planet will sweep out equal areas of the ellipse in equal times.

iii. The square of the period of a planet varies directly as the cube of the radius (the semi major axis). The constant $k=r^3/T^2$ is the same for all planets.

9. Show, by using the principles of horizontal motion and Newton's universal law of gravity, that the ratio r^3/T^2 is a constant for all planets. **[5 marks]**

$F_c = F_g$ ✓

$\frac{m_2 4\pi^2}{T^2} = \frac{GM_1 m_2}{r^3}$ ✓ ✓ (m_2 CANCELS)

$\therefore \frac{r^3}{T^2} = \frac{GM_1}{4\pi^2} = \text{Const.}$ ✓ ✓

10. Using data you collected during your research, calculate the mass of the exoplanet Ross128b. **[5 marks]**

$m = \frac{4\pi^2 r^3}{GT^2}$ ✓ (EQU REARRANGED).

$= \frac{4(9.86)(7.42\times10^9)^3}{(6.67\times10^{-11})(855360)^2}$ ✓

$= \frac{1.61\times10^{31}}{48.8}$ ✓ $= 3.30\times10^{29}$ Kg ✓

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Planet	Neptune	Jupiter	Earth	Mercury
Mass (m)	17.23	317.893	1	0.0558
Radius (r)	4496.6	778.3	149.6	57.9
Period (T)	60189	4332.589	365.256	87.969

Where: Mass = (5.976×10^{24} kg) [mass of the earth],
Radius = (1×10^{6} km) [orbital radius around the sun], and
Period = (23h 56m 04.098s) [sidereal day]

11. Calculate the gravitational force between Earth and mercury when they are only a distance apart equal to the difference between their solar orbits.

[7 marks]

EARTH ORBIT = $(149.6)(1\times10^{9}) = 1.496 \times 10^{11}$ m.

MERC ORBIT = $(57.9)(1\times10^{9}) = 5.79 \times 10^{10}$ m.

ORBIT DIFF = 9.17×10^{10} m.

MERC MASS = $(0.0558)(5.976\times10^{24}) = 3.34 \times 10^{23}$ Kg.

$$F = \frac{GM_E M_m}{r^2} = \frac{(6.67\times10^{-11})(5.976\times10^{24})(3.34\times10^{23})}{(9.17\times10^{10})^2}$$

$$\therefore F = 1.58 \times 10^{14} \text{ N}.$$

12. Calculate the radius of Earth which will correspond with a gravitational force of 9.801N acting on a mass of 1.00kg on the surface. Give your answer to the nearest kilometre.

[4 marks]

$$F = \frac{GM_E(m)}{r^2} \quad \therefore r^2 = \frac{GM_E(m)}{F}$$

$$\therefore r^2 = \frac{(6.67\times10^{-11})(5.976\times10^{24})(1)}{9.801}$$

$$r^2 = 4.07 \times 10^{13} \text{ m}$$

$$\therefore r = 6377 \text{ Km}$$

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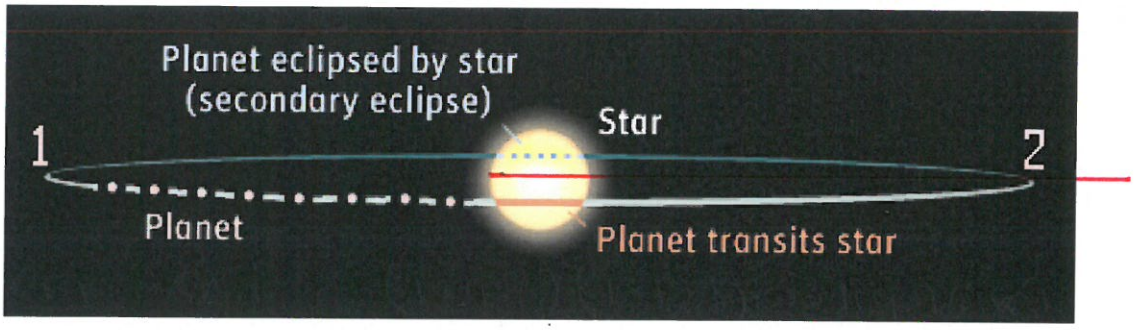
13. Astrophysicists searching the cosmos for possible 'earth-like' planets have discovered a new exoplanet. Each night they take observational data and track the orbiting planet moving from position 1 to position 2 in 14 days. The central star diameter has been measured at 1.39×10^6km.



a) Calculate the mass of the star. **[7 marks]**

FROM PICTURE: DIA OF STAR = 13mm = 1.39×10^9 m.
(FM CENTRE) RAD OF ORBIT = 66 mm = 7.06×10^9 m.

T = 28 DAYS = 2.42×10^6 SECS.

$$m = \frac{4\pi^2 r^3}{GT^2} = \frac{4(9.86)(7.06 \times 10^9)^3}{(6.67 \times 10^{-11})(2.42 \times 10^6)^2}$$

$\therefore$ $m = 3.55 \times 10^{28}$ Kg.

b) Find the gravitational field strength at the star's surface. **[4 marks]**

$$g = \frac{GM}{r^2} = \frac{(6.67 \times 10^{-11})(3.55 \times 10^{28})}{(1.39 \times 10^9)^2}$$

$$= 1.23 \text{ NKg}^{-1}.$$

End of investigation

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