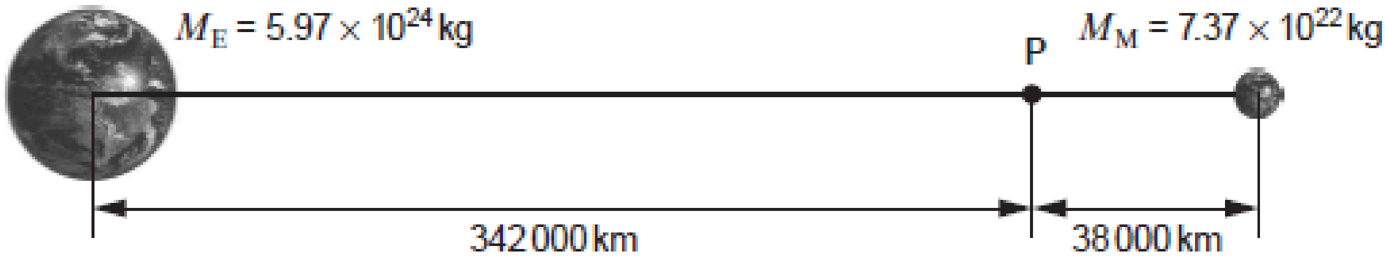
#1

2. (a) Assuming that the Earth is an isolated perfect sphere, draw its gravitational field lines and equipotential surfaces. [3]

(b) (i) Use the information in the diagram to calculate the gravitational potential at point P. [3]



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(ii) Use the information in the diagram to show that the resultant gravitational field at point P is very small. [2]

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(iii) Myfanwy correctly calculates that the force on a 25 tonne spaceship would be negligible at point P and that the force would increase by approximately 0.5 N for every 10 km moved away from point P towards the Earth. Dafydd then concludes that the spaceship will perform simple harmonic motion about point P. Deduce whether or not Dafydd is correct **(no further calculations are required)**. [3]

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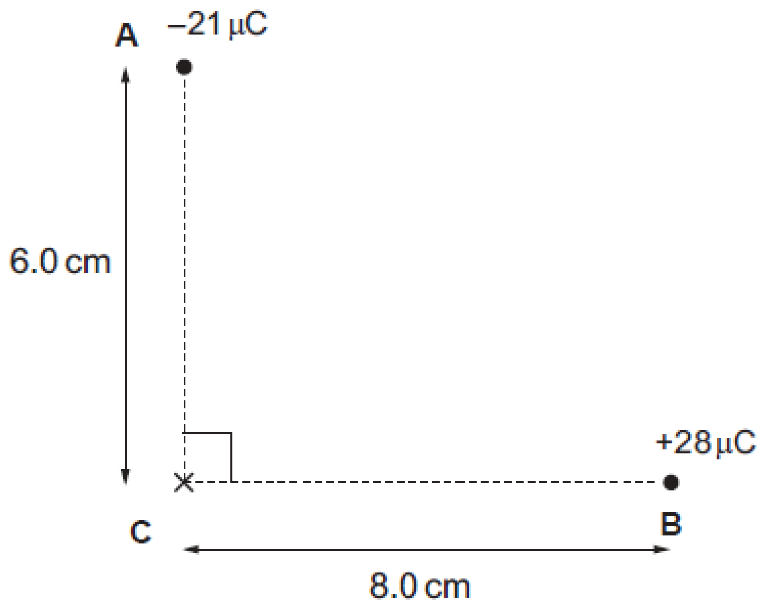
#2

Two charges are placed at points **A** and **B** as shown in the diagram.



(a) Draw **two** arrows on the diagram to represent the directions of the electric fields at **C** due to the –21 μC and +28 μC charges. [2]

(b) Calculate the magnitude and direction of the resultant electric field at **C**. [5]

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(c) Show that the electrical potential at point **C** is zero. [2]

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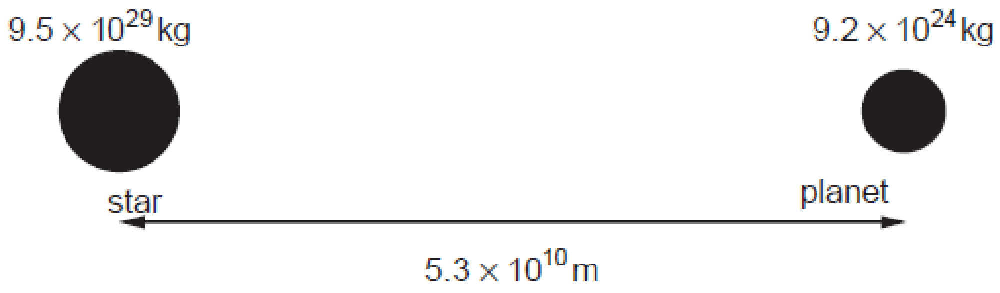
(d) A positron is initially at rest at point **C** and accelerates rapidly due to the electric field. Calculate the potential at the point where the velocity of the positron is $5.4 \times 10^7\,\mathrm{m\,s^{-1}}$. [3]

Question taken from WJEC examination paper 242801, June 2017

#3

The planet (Kepler-186f) orbits the star (Kepler-186) and is considered to be the most Earth-like planet yet discovered. Approximate details of the system are shown in the diagram below.



(a) (i) Show that the radius of orbit of the star around the centre of mass of the system is 513 km. [2]

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(ii) The period of orbit of the planet is 130 days. Calculate the orbital velocity of the star. [3]

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(iii) The velocity calculated in part *(a)*(ii) is small. Explain why small velocities are difficult to measure using red shift. [2]

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(b) (i) Calculate the gravitational force between the star and the planet. [2]

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(ii) An historic alternative to Newton's Law of Gravitation involved invisible steel rods connecting stars and planets and providing the force for keeping planets in orbit. A hypothetical cylindrical steel rod of radius 7.0×10^6 m and length 5.3×10^{10} m joins the planet to the star. Determine whether or not this steel rod is strong enough to keep the planet in orbit and explain why this theory is not accepted. (Breaking stress of steel = 4.5×10^8 Pa.) [4]

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(c) (i) Calculate the potential energy of the star-planet system (see diagram in part *(a)*). [2]

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(ii) In fact the planet has a slightly elliptical orbit. Explain how conservation of energy applies to this elliptical orbit. [2]

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#4

2. *(a)* The escape velocity, v, of a mass, m, from a spherical mass, M, and radius, R, can be calculated using:

$$\tfrac{1}{2}mv^2 - \frac{GMm}{R} = 0$$

(i) Explain how this equation is an application of conservation of energy. [3]

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(ii) Calculate the escape velocity from the Sun ($M_{Sun} = 1.99 \times 10^{30}$ kg, $R_{Sun} = 6.96 \times 10^{8}$ m). [3]

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(b) (i) The temperature of the surface of the Sun is 5 780 K. Use a kinetic theory equation to show that the rms speed of a free electron on the surface of the Sun is approximately 500 km s^{-1}. [4]

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(ii) By considering your answers to *(a)*(ii) and *(b)*(i), explain why the Sun has a slight positive charge. [2]

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(iii) A student claims that a positive charge of approximately 0.08 C on the Sun is enough to produce an electrostatic force equal to the gravitational force on an escaping electron. Determine whether or not she is correct. [3]

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(iv) Estimate the percentage of lost electrons compared with the total number of electrons on the Sun. Assume that the Sun is mainly hydrogen and that it has lost 0.08 C of charge in the form of electrons. [3]

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