

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS  
GCSE**

**A183/02**

**TWENTY FIRST CENTURY SCIENCE  
PHYSICS A/FURTHER ADDITIONAL  
SCIENCE A**

**Module P7 (Higher Tier)**

**MONDAY 23 JUNE 2014: Morning**

**DURATION: 1 hour**

**plus your additional time allowance**

**MODIFIED ENLARGED 24pt**

<b>Candidate forename</b>		<b>Candidate surname</b>	
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<b>Centre number</b>						<b>Candidate number</b>				
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**Candidates answer on the Question Paper.  
A calculator may be used for this paper.**

**OCR SUPPLIED MATERIALS:**

**None**

**OTHER MATERIALS REQUIRED:**

**Pencil**

**Ruler (cm/mm)**

**READ INSTRUCTIONS OVERLEAF**

## **INSTRUCTIONS TO CANDIDATES**

**Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.**

**Use black ink. HB pencil may be used for graphs and diagrams only.**

**Answer ALL the questions.**

**Read each question carefully. Make sure you know what you have to do before starting your answer.**

**Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).**

## **INFORMATION FOR CANDIDATES**

**The quality of written communication is assessed in questions marked with a pencil ().**

**A list of useful relationships is printed on pages 4–7.**

**The number of marks is given in brackets [ ] at the end of each question or part question.**

**The total number of marks for this paper is 60.**

**Any blank pages are indicated.**

# **TWENTY FIRST CENTURY SCIENCE EQUATIONS**

## **USEFUL RELATIONSHIPS**

### **THE EARTH IN THE UNIVERSE**

$$\text{distance} = \text{wave speed} \times \text{time}$$

$$\text{wave speed} = \text{frequency} \times \text{wavelength}$$

### **SUSTAINABLE ENERGY**

$$\text{energy transferred} = \text{power} \times \text{time}$$

$$\text{power} = \text{voltage} \times \text{current}$$

$$\text{efficiency} = \frac{\text{energy usefully transferred}}{\text{total energy supplied}} \times 100\%$$

# EXPLAINING MOTION

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$\text{momentum} = \text{mass} \times \text{velocity}$$

$$\text{change of momentum} = \text{resultant force} \times \text{time for which it acts}$$

$$\text{work done by a force} = \text{force} \times \text{distance moved in the direction of the force}$$

$$\text{amount of energy transferred} = \text{work done}$$

$$\text{change in gravitational potential energy} = \text{weight} \times \text{vertical height difference}$$

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times [\text{velocity}]^2$$

## **ELECTRIC CIRCUITS**

$$\text{power} = \text{voltage} \times \text{current}$$

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

$$\frac{\text{voltage across primary coil}}{\text{voltage across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$$

## **RADIOACTIVE MATERIALS**

$$\text{energy} = \text{mass} \times [\text{speed of light in a vacuum}]^2$$

# OBSERVING THE UNIVERSE

$$\text{lens power} = \frac{1}{\text{focal length}}$$

$$\text{magnification} = \frac{\text{focal length of objective lens}}{\text{focal length of eyepiece lens}}$$

$$\text{speed of recession} = \text{Hubble constant} \times \text{distance}$$

$$\text{pressure} \times \text{volume} = \text{constant}$$

$$\frac{\text{pressure}}{\text{temperature}} = \text{constant}$$

$$\frac{\text{volume}}{\text{temperature}} = \text{constant}$$

$$\text{energy} = \text{mass} \times [\text{speed of light in a vacuum}]^2$$

**Answer ALL the questions.**

- 1 In the late 1700s, the Titius-Bode Law was published.**

**The law was used for calculating the distance of the planets from the Sun. The distance from the Earth to the Sun is 1AU. This is what the law says:**

**To find the distance in AU:**

**take the sequence of numbers 0, 3, 6, 12, 24, 48, 96, ... (each number after the first two is double the previous number)**

**add 4 to each number in the sequence**

**divide each number by 10 to give the distance.**



<b>Titius-Bode distance calculation in AU</b>	<b>Planet</b>	<b>Actual distance from Sun in AU</b>
<b><math>(0 + 4)/10 = 0.4</math></b>	<b>Mercury</b>	<b>0.39</b>
<b><math>(3 + 4)/10 = 0.7</math></b>	<b>Venus</b>	<b>0.72</b>
<b><math>(6 + 4)/10 = 1.0</math></b>	<b>Earth</b>	<b>1.00</b>
<b><math>(12 + 4)/10 = 1.6</math></b>	<b>Mars</b>	<b>1.52</b>
<b><math>(48 + 4)/10 = 5.2</math></b>	<b>Jupiter</b>	<b>5.20</b>
<b><math>(96 + 4)/10 = 10</math></b>	<b>Saturn</b>	<b>9.54</b>

**(a) Suggest why the Titius-Bode Law was only applied to the six planets out to Saturn in the first instance.**

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**[1]**

**(b) Bode thought there should be a planet between Mars and Jupiter.**

**(i) Calculate the distance using the Titius-Bode Law.**

**distance = \_\_\_\_\_ AU [2]**

**(ii) In 1801, the astronomer Giuseppe Piazzi discovered a new planet, *Ceres*, at a distance of 2.77 AU from the Sun. Does this support the Titius-Bode Law? Explain why.**

\_\_\_\_\_  
\_\_\_\_\_ **[1]**

**(iii) Giuseppe Piazzi did not make enough observations to describe the orbit of *Ceres*. Other astronomers could not find the planet.**

**Why is it important that other astronomers observe the new planet?**

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**[2]**

(c) The table below gives the data for other more recently discovered planets.

Titius-Bode calculation of distance in AU	Planet	Actual distance from Sun in AU
$(192 + 4)/10 = 19.6$	Uranus	19.18
$(384 + 4)/10 = 38.8$	Neptune	30.06
$(768 + 4)/10 = 77.2$	Pluto	39.44

Discuss how these results affect confidence in the Titius-Bode Law.

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[4]

**(d) Most scientists think the Titius-Bode Law was just an interesting coincidence.**

**What would be needed to persuade them that the law was not just a correlation?**

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**[1]**

**[TOTAL: 11]**

**2 One of the most distant objects visible to the naked eye is the Andromeda galaxy.**

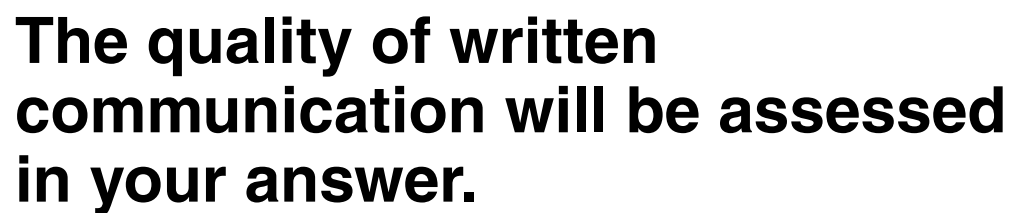
**Edwin Hubble first measured the distance to the Andromeda galaxy using Cepheid variables. He measured the distance as about 1 million light years. Modern measurements using Cepheid variables, give a distance of 2.5 million light years.**

**Telescopes in space have made it possible to make better measurements of parallax and of the brightness of stars.**

**Explain:**

**how using space telescopes gives better measurements of parallax and brightness**

**how this improves measurement of distance to Cepheid variables.**



**[TOTAL: 6]**

**3 Measurements of the distance to galaxies give a value of the Hubble constant as 71 km/s per Mpc.**

**(a) At what distance is a galaxy with a speed of recession of 1800 km/s?**

**distance = \_\_\_\_\_ units \_\_\_\_\_ [3]**

**(b) Explain why there is a relationship between the distances to far galaxies and their speeds of recession.**

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**[2]**



**(c) Scientists can only observe galaxies. They cannot do experiments on the galaxies. Why are scientists confident that the relationship between speed of recession and distance of far galaxies is correct?**

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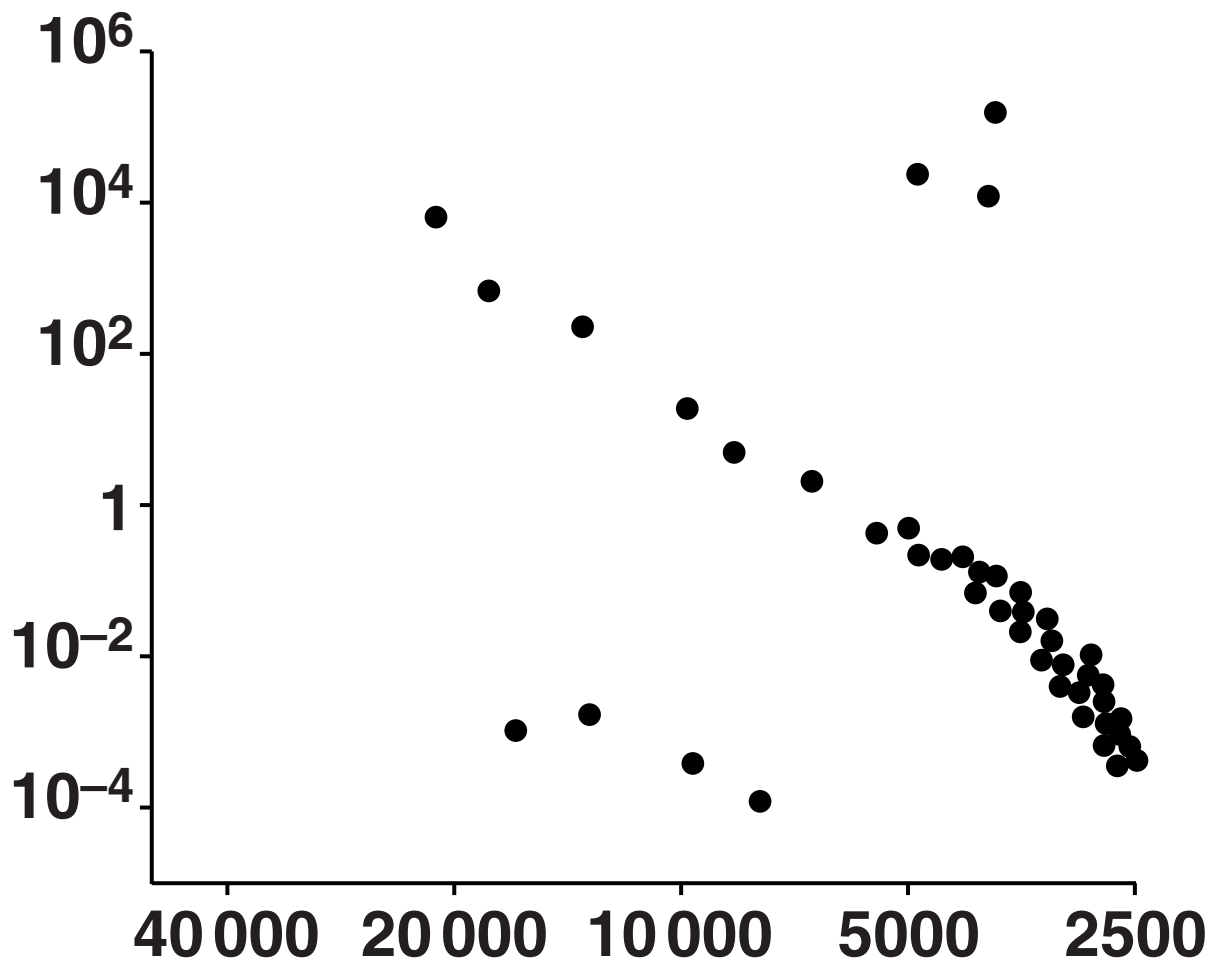
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**[2]**

**[TOTAL: 7]**

**QUESTION 4 BEGINS ON PAGE 18**

4 This graph is a Hertzsprung-Russell diagram.



(a) The labels on the axes of the Hertzsprung-Russell diagram are missing.

What should they be?

horizontal axis \_\_\_\_\_

unit \_\_\_\_\_

vertical axis \_\_\_\_\_

[3]

**(b) One of the axes can also be shown as the colour of a star.**

- (i) On the Hertzsprung-Russell diagram label this axis with the colours blue, red and yellow. [2]**
- (ii) Explain the relationship between the colours and the numbers on this axis.**

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**[2]**

(c) (i) On the Hertzsprung-Russell diagram, put a ring around a star that produces most of its energy by the fusion of hydrogen. [1]

(ii) Explain how scientists know that there is hydrogen in stars.

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[2]

(d) Why can black holes not be plotted on the Hertzsprung-Russell diagram?

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[1]

[TOTAL: 11]

- 5 (a) A star's mass is one of the most significant factors affecting the life of the star.**

**Describe and explain how mass affects the life of a star.**



**The quality of written communication will be assessed in your answer.**

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**[6]**

- (b) A star with a mass of the Sun converts about  $10^{-5}$  of its mass to energy in the fusion of hydrogen.**

**The Sun's mass is  $2 \times 10^{30}$  kilograms.**

- (i) How much mass is converted to energy during the fusion of hydrogen for the star?**

**mass converted**

**\_\_\_\_\_ kg [1]**

**(ii) The luminosity of the star is about  $4.5 \times 10^{26} \text{ J/s}$ .**

**Show that the star converts about  $5 \times 10^9 \text{ kg}$  to produce this amount of energy each second.  
speed of light =  $3 \times 10^8 \text{ m/s}$**

**[2]**

- (iii) A similar star, with the same luminosity, fuses  $3 \times 10^{25}$  kg during the main part of its lifetime.**

**Calculate how long the main part of its lifetime is.**

**lifetime = \_\_\_\_\_ seconds [2]**

**[TOTAL: 11]**



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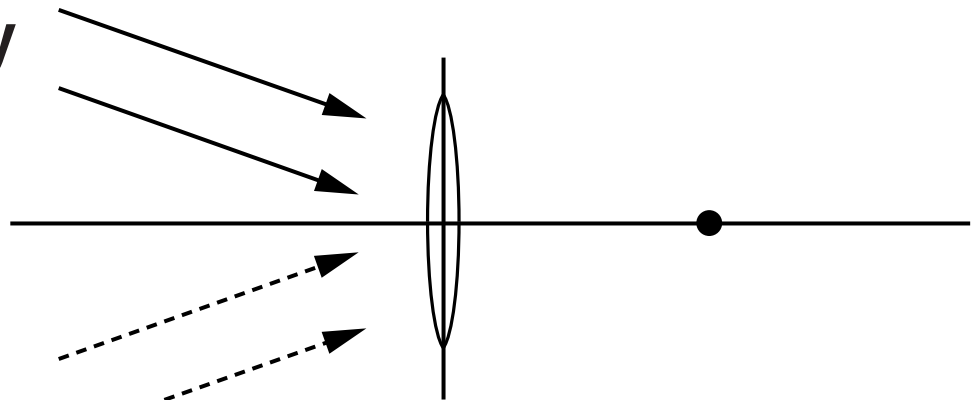
- 6 (a) Complete the ray diagram to show how an image of a distant galaxy is formed.

The point to the right of the lens is the focal point.

Label the image.

light from top  
of galaxy

light from  
bottom of galaxy



[4]

- (b) In a telescope, the objective lens has a longer focal length than the eyepiece lens.

Explain why.

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[2]

**(c) What are the advantages of using a mirror in place of the objective lens in a telescope?**

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**[2]**

**[TOTAL: 8]**

- 7 The table opposite gives some information about possible sites for a new astronomical observatory. Which site would be the best for an astronomical observatory? By considering each site, explain and justify your choice.**



**The quality of written communication will be assessed in your answer.**

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**[6]**

<b>Site</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>Height above sea level in m</b>	<b>5000</b>	<b>1000</b>	<b>6000</b>	<b>500</b>
<b>Average cloudless nights per year</b>	<b>360</b>	<b>120</b>	<b>270</b>	<b>230</b>
<b>Average % water in air</b>	<b>10</b>	<b>20</b>	<b>0</b>	<b>15</b>
<b>Distance to nearest town in km</b>	<b>100</b>	<b>150</b>	<b>50</b>	<b>30</b>
<b>Result of Environmental survey</b>	<b>local rare species</b>	<b>no survey</b>	<b>very few living organisms</b>	<b>no survey</b>

**[TOTAL: 6]**

**END OF QUESTION PAPER**

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