



DEPARTMENT OF PHYSICS AND ASTRONOMY

Spring Semester 2006-2007

EXTRA-SOLAR PLANETS AND ASTROBIOLOGY

2 HOURS

Answer THREE questions.

Each question carries 10 marks.

A formula sheet and table of physical constants is attached to this paper.

The breakdown on the right-hand side of the paper is meant as a guide to the marks that can be obtained from each part.

TURN OVER

1.

- (a) One of the equations required to determine the mass and semi-major axis of a planet around a star is the general form of Kepler's third law,

$$P^2 = a^3 \left(\frac{4\pi^2}{GM_*} \right),$$

where P is the planet's orbital period, a is its orbital semi-major axis, M_* is the mass of the star and G is the gravitational constant.

Derive the second equation that relates the observed radial velocity, $V_* \sin i$, of the parent star to the minimum mass, $M_p \sin i$, of the planet:

$$M_p \sin i = \frac{V_* \sin i P}{2\pi a} M_*.$$

Explain what is significant about the angle i . [3]

- (b) Briefly discuss the limitations of the Doppler method of planet finding. [2]

- (c) Sketch the period-radial velocity curve (in m s^{-1} vs. years) of a Solar mass star which has a planet of mass $M_p \sin i = 3.8 \times 10^{27} \text{ kg}$ ($= 2M_{\text{jup}}$) in a circular orbit of radius 0.5 AU. [2]

Sketch what the period-radial velocity curve of the star would look like if this system *also* contains a planet with an orbital period of 1 year which causes a radial velocity variation of 20 m s^{-1} in the star. [1]

- (d) A star orbits the centre of mass of a system in an elliptical orbit. Sketch typical radial velocity curves as viewed along the semi-major and semi-minor axes of the ellipse. [2]

2.

- (a) Describe the fundamental properties of a cell. [3]
- (b) What are the differences between prokaryotic and eukaryotic cells? [1]
- (c) Why was the development of eukaryotic cells crucial to the development of advanced life on Earth? [1]
- (d) What are proteins and why are they essential for life on Earth? [2.5]
- (e) Briefly describe how the information stored in DNA is read and turned into a protein. [2.5]

3.

- (a) What were the major geological eons in the Earth's history? Describe the important events and types of life that were present on the Earth during these eons. [4]
- (b) Explain how we think the surface temperature of the Earth has remained relatively stable over geological time. [4]
- (c) How could life on Earth be detected from outside the Solar System? [2]

4.

- (a) Describe the evidence for a warm, wet past on Mars. [3]
- (b) Describe the experiments conducted by the Viking landers to look for life on Mars. What were the results of each experiment and how have they been interpreted? [4.5]
- (c) Apart from the Earth and Mars, which planets or moons in the Solar System have the most chance of harbouring life and why? [2.5]

5.

- (a) What is the Fermi Paradox? [1]
- (b) Describe and critically examine any THREE proposed solutions to the Fermi Paradox. [3×3]

END OF QUESTION PAPER