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Name:_____

Student ID:_____

ASTRONOMY 1F03 MIDTERM EXAMINATION

Thursday October 20th, 2016; 7:00—8:30pm

INSTRUCTIONS: Answer all questions in the spaces provided. Write brief, concise, explanatory answers. No books or notes are allowed. University approved calculators are allowed. This exam has 10 questions on 4 pages, check that your copy is complete.

1. What is a solar eclipse? What is the phase of the Moon during a solar eclipse? Describe why we sometimes get a total solar eclipse and sometimes an annular eclipse. What is special about the Sun and Moon that allows this variety of solar eclipses?

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4 – Moon in line between Earth & Sun, fully or partially covering Sun when viewed from some point on Earth

2 – New Moon

4 – Moon's orbit is slightly elliptical, when closer to Earth can get a total eclipse, when further away may appear too small to fully cover Sun

2 – Both Sun and Moon subtend nearly the same angle from Earth (~½°)

2. If, instead of its current axial tilt of 23.5°, the Earth had a different axial tilt, describe the seasons and day/night cycle for a place with a latitude like Hamilton's (about 43° N) for the following two cases (assume that the orbital and rotation periods are unchanged):

   a. An axial tilt of 0°

   - No seasons Day & night of equal length all year

3

(10)

   b. An axial tilt of 90°

- start at midwinter (S pole pointing directly at Sun)
- night until ~ mid Feb
- mid Feb → sun briefly on S. horizon, thereafter day length grows until it reaches 12hr Mar 21st
- day length grows until about mid May when Sun no longer sets
- day until ~ mid Aug
- reverse back to mid winter

7

3. Kepler's laws

a. State Kepler's three laws for objects in orbit about the Sun.

2 I elliptical orbits with Sun at one focus

2 II equal areas swept out by lines joining planet and Sun in equal times

2 III $P^2 = a^3$; P, period in years
a, semi-major axis in AU

b. The orbit of a small body in the solar system has a perihelion distance of 0.4AU and an eccentricity of 0.996. What is its aphelion distance and what is its period? What category of solar system object is this likely to be?

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Perhelion distance $= a(1-e)$; Aphelion $= a(1+e)$

2 - $a = \frac{0.4\,AU}{1-0.996} = 100\,AU \Rightarrow$ Aphelion $= 2a - 0.4AU = 199.6\,AU$

2 - $P = a^{3/2} = 1000\,yrs$

2 - A comet most likely from Oort cloud (long period)

4. Tides

a. Describe the origin of the ocean tides on Earth. Why do we get two tides per day?

(10)

7 - Moon (& to a lesser extent, Sun) exerts varying pull on Earth due to Earth's finite size. Differential forces act on oceans & body of Earth. Earth responds only slightly; water much more

Moon-O

Arrows show differential gravitational forces due to Moon

two tides

b. The *differential* (or tidal) acceleration across the Earth (diameter, d) due to a mass, M, at distance, R, is approximately $a = G\,M\,d\,/\,R^3$ where G is Newton's constant. Given that the Sun is 30,000,000 times the mass of the Moon and is 400 times further away from Earth than the Moon, calculate the **ratio** of the tidal accelerations on Earth due to the Sun and Moon.

3

$$\frac{a_{sun}}{a_{moon}} = \frac{3\times10^7}{(400)^3} = 0.47$$

5. Planetary atmospheres
   a. Briefly describe the (Jeans') theory for the retention or loss of gases in planetary atmospheres.

8 (10)

- compares escape velocity of planet (v_{esc}) with mean speed of atmosphere molecules, v_{av}
- molecular speeds depend on temperature (higher for higher T) and molecular mass (lower for higher mass)
- Can retain molecules if $6 \cdot v_{av} \leq v_{esc}$

   b. State two reasons why Jupiter can retain Hydrogen in its atmosphere whereas the Earth cannot.

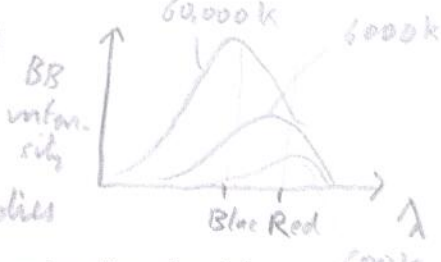
2

Jupiter's escape velocity is higher and its temperature is lower

6. The Sun has a surface temperature of about 6,000K, a wavelength of peak emission of 480nm and appears yellow. What would be the peak wavelength and colour of a 600K star and of a 60,000K star? Explain the physical basis for your answers.

(10)

- Wien's Law $\lambda_{max} \propto \frac{1}{T}$ for a blackbody
- 2 - 600K $\Rightarrow \lambda_{max} = 4800$nm red
- 2 - 60,000K $\Rightarrow \lambda_{max} = 48$nm blue
- 6 - stars reasonably approximated by blackbodies



7. What is an absorption spectrum and how is it formed? Your explanation should make reference to the quantum nature of the atom. Why do most stars exhibit absorption spectra? List two pieces of information we can gain from studying stellar spectra?

- composition
- temp
- excitation
- density
- motion

2

6 - Continuous spectrum less dark lines. Get absorption spectrum when viewing hot continuous source through cooler, low density gas. Photon from continuum source with exact energy to excite allowed transition in low density gas atoms/molecules will be absorbed. When de-excitation occurs, photons are emitted in a random direction leading to a deficit at those energies/wavelengths.

(10)

2 - centre of star acts as its source, upper layers are cooler, lower density gas

8. List the advantages of making astronomical observations from space.

- no weather (optical)
- diffraction-limited resolution (i.e., no seeing limit for optical)
- wider range of wavelengths available

(4) for two advantages

9. Exoplanets
   a. An extra-solar planetary system is viewed edge-on from Earth. The sun-like star has a radius of 700,000km. If the planet causes a 1% dip in brightness of the star when it transits, calculate the radius of the planet.

3 $\left(\frac{R_{planet}}{R_{star}}\right)^2 = 0.01 \Rightarrow R_{planet} = 70{,}000\ km$

(6)

   b. If the orientation of the system does not lead to transits, how else might we infer the presence of a planet around a distant star?

3 - Look for motion of star about star-planet centre of mass using periodic Doppler shift of spectrum.

10. It is believed that each of Venus, Earth and Mars had a thick CO_2 atmosphere at early times. For each of these planets state where the CO_2 has gone since.

2 - Venus: very hot surface/atmosphere results in little CO_2 in surface rocks

(6)

2 - Earth: most CO_2 in surface rocks; balance between release due to tectonic activity and absorption by rocks/oceans

2 - Mars: essentially all CO_2 in surface rocks - little tectonic activity to return CO_2 to atmosphere

THE END