NAME: EXAM SOLUTIONS

BUCKNELL UNIVERSITY
Astronomy 101

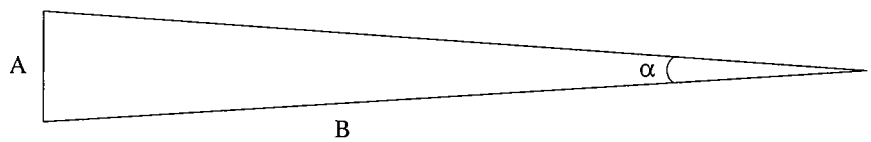
First Hour Exam — 2005 September 21

This exam will be scored on a 100 point scale and has three parts:
1) a multiple choice section containing 6 questions each worth 4 points,
2) a short answer section containing 4 questions each worth 9 points, and
3) a problem section containing 2 problems worth 20 points each.

Below are some relationships you might find useful:

for a circle:	circumference = 2 π radius
for an ellipse:	eccentricity = f/a
Kepler's Third Law:	$(\text{Period})^2 = (\text{semi-major axis})^3$
acceleration:	acceleration = change in speed per time or $a = \frac{\Delta v}{\Delta t}$
for circular orbits:	speed^2 = radius x acceleration
gravitational acceleration at the Earth's surface:	9.8 m/s^2
for constant acceleration:	distance = 1/2 acceleration x time^2 or $d = 1/2\ a\ t^2$
radius of the Earth:	6.379 x 10^6 m
mean Earth-Moon distance:	3.84 x 10^8 m
1 Astronomical Unit (A.U.)	1.496 x 10^{11} m
the speed of light:	3.00 x 10^8 m/s
the speed of sound:	330 m/s
number of seconds in a year:	3.16 x 10^7 sec/yr

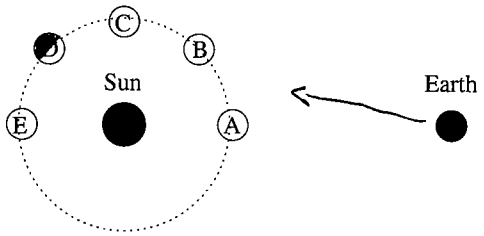
The Observer's Triangle Relation:



$$\frac{\alpha}{57.3^\circ} = \frac{A}{B}$$

Multiple Choice Questions (4 points each)

MC1. Below is a diagram of the Earth, Sun, and Mercury at several positions in its orbit (each position is labelled with a letter from A to E).



For which position of Mercury would you likely measure a fractional illumination (f) of 0.8?

a) A

b) B

c) C

d) D

e) E

MC2. Which of the following statements is *false* regarding Ptolemy's geocentric model?

a) The Earth is not at the center of the planets' circular orbits. TRUE. THE EARTH IS "EX-CENTRIC

b) Retrograde motion is accounted for with the addition of epicycles to each planet's orbit. YUP.

c) The planets move at constant speed. TRUE. The planets move at constant speed on their epicycles

d) The stars do not move.

e) The Earth is stationary. Yup.

MC3. A star is directly overhead at the North Pole. What is the southernmost latitude at which this star can be seen?

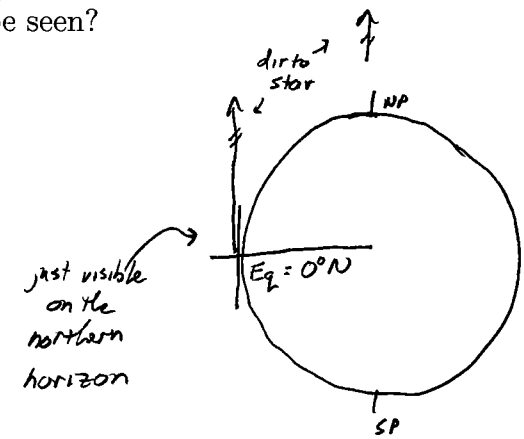
a) 90° N

b) 30° N

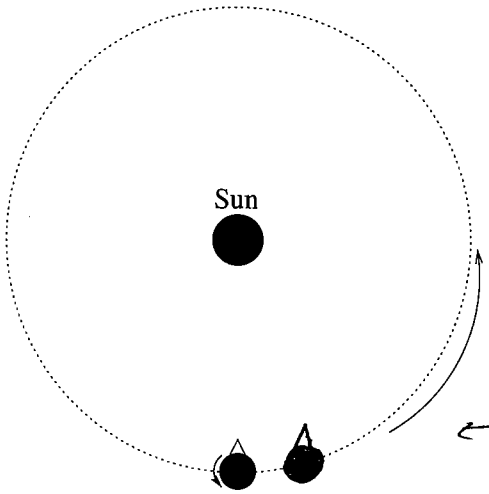
c) 0° N

d) 30° S

e) 90° S



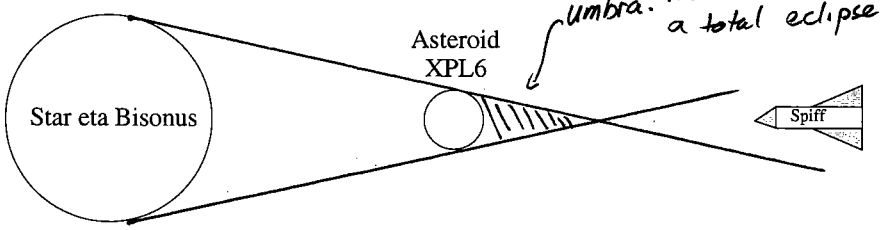
MC4. The diagram below shows the Earth in orbit around the Sun. At the precise moment of ths diagram, Mt. Everest (the white triangle in the diagram) is pointing toward the Sun.



← Mt. Everest points in to the same direction in space, without regard to the Sun

In this diagram, draw the Earth's position **one sidereal day later.** Please note the arrows that indicate the direction of the Earth's rotation on its axis and its revolution around the Sun. Don't forget to include Mt. Everest in your drawing.

MC5. In the diagram below, the asteroid XPL6 passes directly between Spaceman Spiff and the giant star *eta Bisonus*.



umbra. Hafta be in here to see a total eclipse.

Spiff sees an annular eclipse:

Based on the relative sizes of the star, planet, and Spiff's spaceship, does Spiff see a total eclipse?

a) Yes.

b) No.

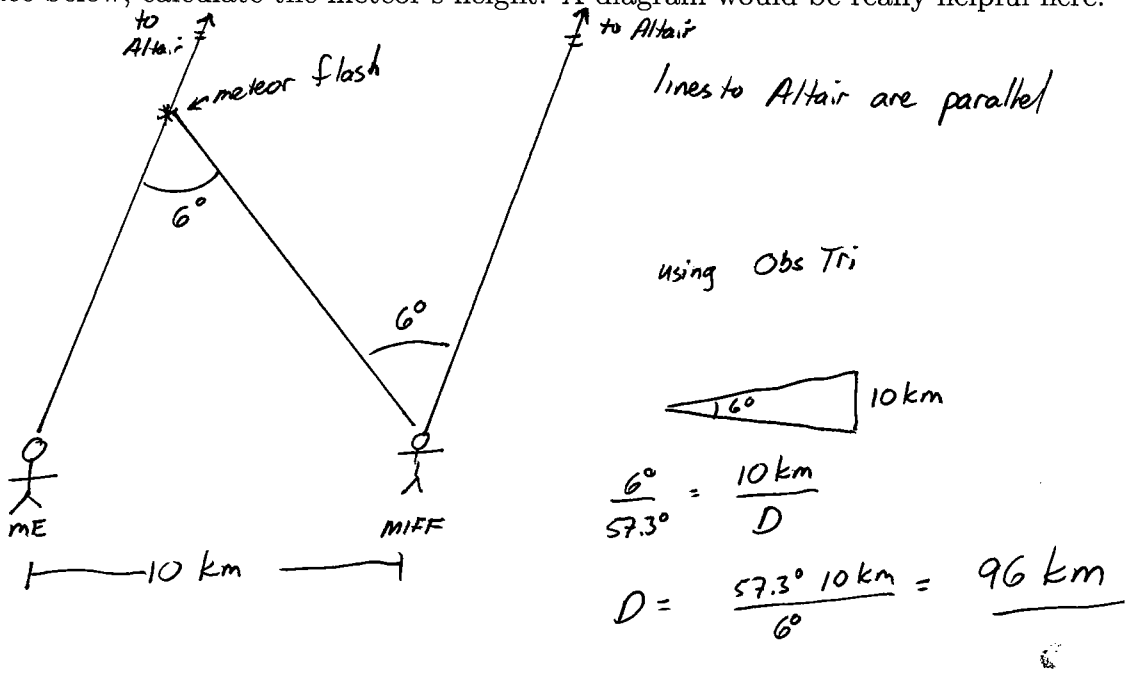
c) Can't tell from this diagram.

MC6. In the space below, explain in one sentence why Galileo's discovery of the moons of Jupiter was so important to heliocentrists.

Galileo found something that didn't orbit the Earth.

Short Answer Questions (**9 points each**)

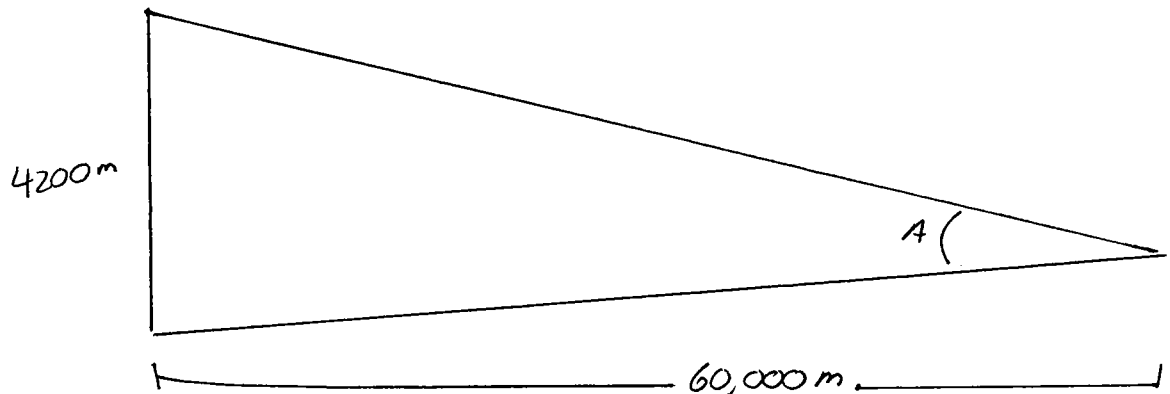
SA1. You are talking to your friend in Mifflinburg, about 10 km away. During the conversation you both see a meteor flash across the sky. You say "Wow! That was a neat meteor. It passed directly in front of the star Altair." Your friend says, "That's funny – from my perspective, it looked like the meteor passed six degrees to the east of Altair." Luckily, you're an ASTR101 student, and you know that with this information you can figure out how far above you and your friend the meteor was when it glowed so brightly. In the space below, calculate the meteor's height. A diagram would be really helpful here.



SA2. Give at least two reasons why astrology is not considered a true science. (Note that I'm *not* asking why astrology is wrong – just why it's not *scientific.*)

- astrology posits no causal connection between celestial events and terrestrial events
- astrology ignores failed tests & contradictory evidence
- astrology has not changed or evolved in response to observations and/or new evidence
- astrologers cannot replicate each others measurements/predictio i.e., no common interpretation of identical datasets

SA3. Mauna Kea is a 4200 m tall volcano on the Big Island of Hawaii. If you view this volcano from the town of Hilo, about 60 km away from Mauna Kea, what is the volcano's angular size?



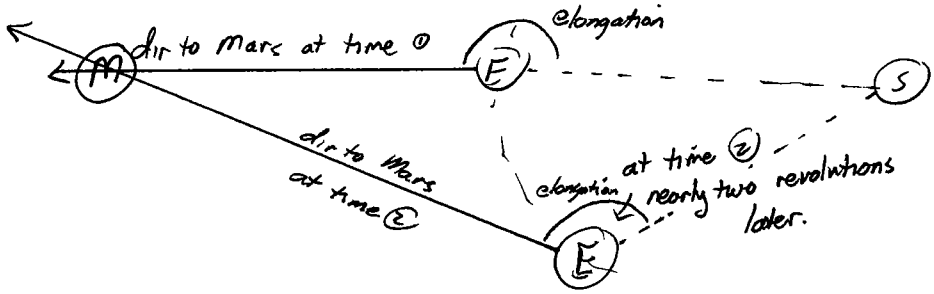
$\frac{A}{57.3^\circ} = \frac{4200\,m}{60000\,m} \Rightarrow A = 57.3^\circ \frac{4200\,m}{60000\,m} = 4^\circ$

SA4. Explain how Kepler was able to show that the orbit of Mars was not circular, nor was it centered on the Sun. Diagrams will help a lot here.

Kepler mapped out Mars' actual position using Tycho's dataset.

1) He picked a time when Mars was at opposition
2) He then looked at Mars' elongation one martian year (687 Earth days) later. Mars was in the same position, but the Earth was not

Where these lines crossed, Mars must be located.



He does this for many locations in Mars' orbit & maps out Mars' actual position as a function of time in its orbit.

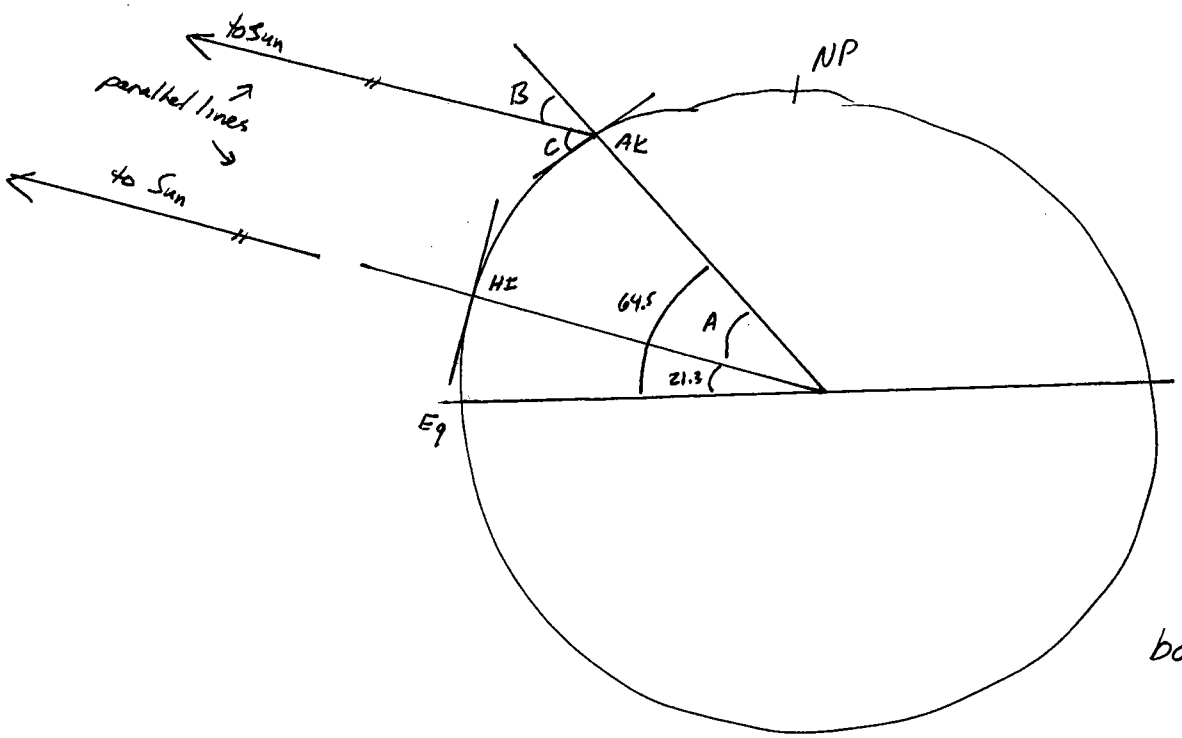
He then ~~tried~~ tries to figure out the shape of Mars' orbit directly from the data. A circle won't work, so he comes up with the ellipse.

Problems

Show your work! I will be very generous with partial credit if I can figure out what you're doing!

P1. On May 27, the Sun is directly over Honolulu, HI (latitude = 21.3 degree north) at noon. On that same day, what is the altitude of the Sun in Fairbanks, Alaska (latitude = 64.5 degrees North) at noon? (**20 points**)

Note: To obtain full credit for this problem, you need to show me a diagram indicating the positions of Honolulu and Fairbanks, the vertical and horizontal directions at each position, and the direction to the Sun at each position. Furthermore, you need to justify your answer with geometric and algebraic relationships. Remeber, your goal should be to persuade me that you know what you're doing.



$A = 64.5 - 21.3$
$= 43.2°$

$B = A$
because the lines to the Sun from both locations are parallel.

$C = 90 - B$
$= 90 - 43.2$
$= \underline{46.8°}$ is the altitude of the Sun in Fairbanks at noon on 27 May.

P2. The planet Uranus has a period of 84 years.

a) Calculate the semi-major axis of Uranus' orbit. (**6 points**)

$$P^2 = a^3$$

$$84^2 = a^3$$

$$\sqrt[3]{84^2} = a$$

$$19.1\ A.U = a$$

b) Assuming that Uranus' orbit has zero eccentricity, calculate the speed of this planet as it orbits the Sun. (**10 points**)

$$\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{t} = \frac{2\pi (19.1)}{84} = 1.43\ AU/yr$$

correct answers in other units: $2.14 \times 10^{11}\ m/yr$

$6.79 \times 10^{3}\ m/s$

c) Calculate the acceleration of Uranus in its orbit. (**4 points**)

for a circle, $\text{acceleration} = \frac{\text{speed}^2}{\text{radius}} = \frac{(1.43\ AU/yr)^2}{19.1\ AU} = 0.107\ AU/yr^2$

correct answers in other units: $1.6 \times 10^{10}\ m/yr^2$

$1.6 \times 10^{-5}\ m/s^2$