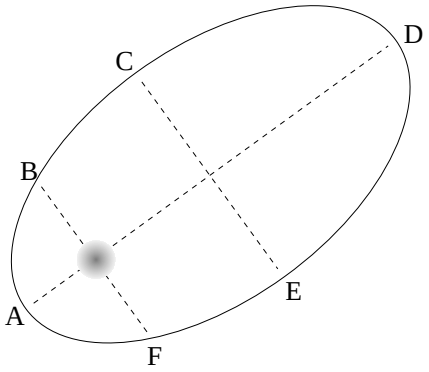
Gravitation -- Conceptual Questions

1.) It is the gravitational attraction between the moon and the oceans that causes the bulge we associate with high tide. So why do we observe *two* high tides at a given time of the day, one on either side of the earth?

2.) The elliptical orbit of a planet moving around its star is shown as a solid line in the sketch. Justifying each response, at which points will the planet have the same:

a.) Momentum?
b.) Angular momentum?
c.) Mechanical energy?
d.) Orbital velocity?
e.) Angular velocity?
f.) Planetary acceleration?
g.) Net force?
h.) Torque?



3.) Newton's general expression for the gravitational force on any mass m due to the presence of a second mass M is GmM/r^2, where r is the distance between the center of mass of the two bodies. What one might deduce from this is that if we put an object at the center of the earth, the distance between the earth's center of mass and the object's center of mass would be zero . . . and the force would be infinite. This obviously makes no sense. Explain your way out of the problem.

4.) For the gravitational force function GmM/r^2, where would you expect its potential energy function to have its zero?

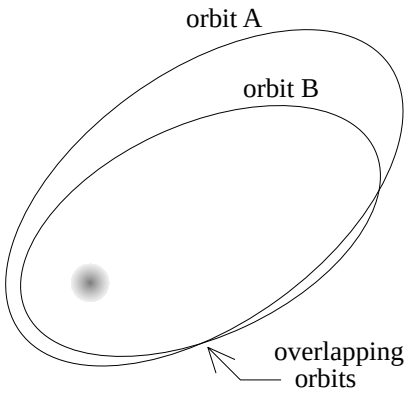
5.) In the case of a circular orbit, what *kind* of force is gravity?

6.) Assuming you were invincible:

a.) What would happen to your weight if you stood on the surface of an imploding star (i.e., a structure whose mass isn't changing but whose outer radius is decreasing)? Explain.
b.) What would happen to your weight if you stayed stationary where the surface had been as the star implodes underneath you?

7.) Two moons orbit in *exactly* the same circular orbit around a planet. Is it possible for one of the moons to orbit faster than the other? Explain.

8.) Two moons in different elliptical orbits share part of their respective orbits with one another (that is, assume their orbits partially overlap).



a.) Which of the two orbits will, on average, require the largest average velocity to hold?

b.) The chances are slim that both moons would be found in the overlapping part of their orbits at the same time, but let's assume that that has happened. If the moon in the rear is moving a little faster than the moon in front, will the two ultimately collide? Explain. (Assume there *is* time for the rearmost moon to catch the front moon before the two orbits diverge.)

9.) The acceleration of gravity at the moon's surface is one sixth the gravitational acceleration at the earth's surface. If you moved to twice the moon's radius, what will the gravitational acceleration be?

10.) Assuming the earth was homogenous, how would you expect your weight to change as you moved downward into a vertical mining shaft? Be specific (that is, will it change linearly, exponentially, quadratically, what?). Would things be different if the earth had a thin crust several miles thick with molten magma below it?

11.) Assume the radius of the earth is r. At r, the gravitational acceleration is g. If you could compress all of the earth's material into a ball whose radius was $r/2$, how would the gravitational acceleration at r change?

12.) Assume two planets have equal, homogeneous mass distributions. If one planet has half the radius of the other, how will the escape velocity differ between the two?

13.) How would the earth's motion be affected if the sun was magically transformed into a black hole? This is not a supernova situation. The sun isn't blowing up, it's just suddenly, magically dropped its radius to, maybe, one mile across.

14.) Assume there are three equal radius, equal mass moons orbiting a planet. One moon is homogeneous, the second has almost all of its mass at its center, and the third has almost all of its mass in a thin crust at its surface. Ignoring any effect from the planet, which will have the greatest acceleration of gravity at its surface?

15.) As far as fuel goes, would it take more to go from Earth to Jupiter or from Jupiter to Earth?

16.) Why doesn't the moon fall into the earth?

17.) Due the gravitational force the earth exerts on the moon, the moon essentially *falls around the earth*. But according to Newton's Third Law, that means there must be an equal and opposite gravitational force that the moon exerts on the earth. So why doesn't the earth fall around the moon?

18.) Consider a planet with half the earth's mass and a third of its radius.
   a.) Is the planet's density the same as the earth's?
   b.) What would the gravitational acceleration be on the planet's surface?

19.) If you know the period T (i.e., the time for one revolution) of a satellite in circular motion about an object of known mass M, can you determine the satellite's radius r of motion? If so, how so? If you additionally know the radius, is there some clever way you can determine its speed v?

20.) Assuming the earth's mass is approximately 80 times the moon's mass, and noting that the acceleration of gravity on the moon is approximately 1/6 that of the acceleration of gravity on earth, what can you say about the relationship between the moon's and earth's radius?

21.) Two moons orbit a large planet in approximately circular paths. The first moon is twice as far from the planet's center as is the second moon.
   a.) What is the ratio of their speeds?
   b.) What is the ratio of their total energies?
   c.) How would the answers have changed (bigger, smaller, what?) if the distances given had been from the planet's surface?

22.) When a satellite orbits a planet in an elliptical orbit:
   a.) Does the planet do work on the satellite as it moves?
   b.) What is the net work done per orbit? Explain.

23.) An object positioned a distance $10R$ units out from the center of a star of radius R begins its fall from rest toward the star. As the freefall proceeds
   a.) As a function of position, what does a graph of the body's total mechanical energy look like?
   b.) As a function of position, what does a graph of the body's gravitational potential energy look like?

c.) As a function of position, what does a graph of the body's kinetic energy look like?

24.) Stop a circling satellite dead in its tracks, then release it. It will freefall toward the earth. Why? Because there is a gravitational force on the satellite due to the presence of the earth. It isn't a big force (gravity diminishes the farther you get from the earth), but it exists. With that in mind, why do things (sandwiches, hammers, whatever) appear weightless to people who are working in a space station that circles the earth?