Name________________________________

Apr. 26, 2011

Phys 2112, Spring 2011
Quiz #3

1. a) In the derivation of the general orbit for motion from Newton's law of gravity, we originally had factors of $\dot{\phi} \equiv \frac{d\phi}{dt}$ in the equations, but managed to eliminate them. How was that done?

We used the fact that a certain combination of $\dot{\phi}$ and r is a constant, specifically $\ell \equiv mr^2\dot{\phi}^2$. With this we could eliminate $\dot{\phi}$ in favor of using a number (ℓ) which is characteristic of the particular orbit.

b) In what way is the solution, expressed as $r(\phi)$, more useful (and interesting) than the solution we might have gotten, expressed as $r(t)$?

In this form we will get the *shape* of the orbit, i.e. a map of the places it moves to. But we lose information about how r (and ϕ) vary with time.

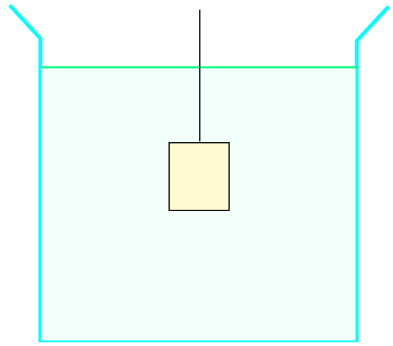
c) What are the possibilities for the shapes of the orbits for an object in motion around a much more massive object? Make a comment about the *position of the massive object* in relation to the orbital shape(s).

The orbit will have the shape of an ellipse if it is closed (with the circle as a special case) or if it is not closed it can be a parabola or a hyperbola. Thus, one of the famous conic sections.

The massive object (which we placed at the origin of our coordinate system) is at **one of the foci** of the conic section.

2. a) A piece of solid copper has mass 0.600 kg. When it is suspended (motionless) from a string while under water, what is the tension in the string?

The density of copper is $8.94\,\frac{\mathrm{g}}{\mathrm{cm}^3}$, *that is,* $8.94 \times 10^3\,\frac{\mathrm{kg}}{\mathrm{m}^3}$.



The buoyant force on the copper is

$$F_b = (\rho_{\text{fl}} V) g = \left(\rho_{\text{fl}} \frac{M}{\rho_{\text{Cu}}}\right) g = \frac{\rho_{\text{fl}} M g}{\rho_{\text{Cu}}}$$

Total force on the metal piece is zero, so

$$T - Mg + \frac{\rho_{\text{fl}} M g}{\rho_{\text{Cu}}} = 0 \qquad \Longrightarrow \qquad T = Mg\left(1 - \frac{\rho_{\text{fl}}}{\rho_{\text{Cu}}}\right)$$

Plug in the numbers:

$$T = (0.600\ \mathrm{kg})(9.80\,\tfrac{\mathrm{m}}{\mathrm{s}^2})(1 - \frac{1.00}{8.94}) = 5.22\ \mathrm{N}$$

Of course, without the water the tension would be $T + Mg = 5.88\ \mathrm{N}$.

b) If the string is attached to a scale (which reads out its results in *kilograms*), what does the scale read?

The scale's maker assumes you don't have the masses sitting in water, so the *mass* reading of the scale is the mass given by $T = mg$. So in this case the scale reads

$$m' = \frac{T}{g} = \frac{5.22\ \mathrm{N}}{9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}} = 0.532\ \mathrm{kg}$$

Show work for all problems and include the right units!

$$F_{\text{grav}} = G\frac{m_1 m_2}{r^2} \qquad G = 6.67 \times 10^{-11}\,\frac{\mathrm{N \cdot m^2}}{\mathrm{kg}^2} \qquad F_c = \frac{mv^2}{R} \qquad g = 9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}$$

$$-G\frac{Mm}{r^2} = m(\ddot{r} - r\dot{\phi}^2) \qquad r\ddot{\phi} + 2\dot{r}\dot{\phi} = 0$$

$$\rho = \frac{M}{V} \qquad F_b = W_{\text{fl-disp}} = \rho_{\text{fl}} V g \qquad \rho_{\text{water}} = 1000\,\frac{\mathrm{kg}}{\mathrm{m}^3} \qquad \rho_{\text{air}} = 1.29\,\frac{\mathrm{kg}}{\mathrm{m}^3} \qquad g = 9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}$$