

**Phys 410**  
**Spring 2013, Prof. Anlage**  
**15 February, 2013**

**Problem 1.** Both the Coulomb and gravitational forces lead to potential energies of the form  $U(\vec{r}_1 - \vec{r}_2) = \gamma/|\vec{r}_1 - \vec{r}_2|$ , where  $\gamma = kq_1q_2$  for the Coulomb force and  $\gamma = -Gm_1m_2$  for gravity, and  $\vec{r}_1$ , and  $\vec{r}_2$  are the positions of the two particles. Show in detail that  $-\nabla_1 U(\vec{r}_1 - \vec{r}_2)$  is the force on particle 1 and  $-\nabla_2 U(\vec{r}_1 - \vec{r}_2)$  is that on particle 2.

Hint: Define  $\vec{r} = \vec{r}_1 - \vec{r}_2$  which is a vector that points from particle 2 to particle 1. The PE is  $U = \frac{\gamma}{r}$  and the forces can be written as  $\vec{F}_{12} = \frac{\gamma}{r^2} \hat{r}$  and  $\vec{F}_{21} = -\frac{\gamma}{r^2} \hat{r}$ .

**Problem 2**

A mass on the end of a spring is oscillating with angular frequency  $\omega$ . At  $t = 0$  its position is  $x_0 > 0$  and I give it a kick so that it moves back toward the origin and executes simple harmonic motion with amplitude  $2x_0$ . Find the position as a function of time in the form  $x(t) = A \cos(\omega t - \delta)$ .