4. (10 pts.) A simple pendulum is composed of a bob of mass 0.4 kg at the end of a rod of length L. The period of oscillation of the pendulum is 2.24s. What is the length of the pendulum?

5. (20 pts.) Consider a particle attached to a horizontal spring undergoing simple harmonic motion of amplitude A and frequency f. The relaxed position of the spring is at the origin.

a. (10 pts.) At what positions will the kinetic and potential energies be equal?

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$$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow \frac{T^2}{4\pi^2} = \frac{L}{g} \Rightarrow L = \frac{gT^2}{4\pi^2}$$

$$L = \frac{(9.8)(2.24)^2}{4\pi^2} = \boxed{1.25\,m}$$

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(a) $E_i = \frac{1}{2}kA^2$. ~~when~~

$E_f = K_f + U_f$ when $K_f = U_f$, $U_f = \frac{1}{2}E_f$, or $E_f = 2U_f$

$$E_i = E_f$$

$$\frac{1}{2}kA^2 = 2\left(\frac{1}{2}kx^2\right)$$

$$A^2 = 2x^2$$

$$\boxed{x = A/\sqrt{2}}$$

(b) max speed: at origin $\frac{1}{2}mv_{max}^2 = E = \frac{1}{2}kA^2$.

$$E_i = E_f$$

$$\frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}kA^2 = \frac{1}{2}m\left(\frac{1}{2}v_{max}\right)^2 + \frac{1}{2}kx^2$$

$$\frac{1}{2}kA^2 = \frac{1}{4}\underbrace{\left[\frac{1}{2}mv_{max}^2\right]}_{\frac{1}{2}kA^2} + \frac{1}{2}kx^2$$

$$\frac{1}{2}kA^2 = \frac{1}{4}\left(\frac{1}{2}kA^2\right) + \frac{1}{2}kx^2$$

$$A^2 = \frac{1}{4}A^2 + x^2$$

$$\frac{3}{4}A^2 = x^2$$

$$\boxed{\frac{\sqrt{3}}{2}A = x}$$