$$W_g \quad = \quad \int_0^H \vec{F}_g \cdot d\vec{y} \quad = \quad \int_0^H |mg| \; |dy| \; \cos(180°)$$

$$W_g \quad = \quad -mg \int_0^H \; dy \quad = \quad -mg(H-0) \quad = \quad -mgH$$

$$\text{GPE} \quad = \quad -W_g \quad = \quad -\int_0^H \vec{F}_g \cdot d\vec{y}$$

$$\text{GPE} \quad = \quad mgy$$

$$F_y \quad = \quad -\frac{\partial(\text{GPE})}{\partial y} \quad = \quad -\frac{\partial(mgy)}{\partial y} \quad = \quad -mg$$

$$F_x \quad = \quad -\frac{\partial(\text{GPE})}{\partial x} \quad = \quad -\frac{\partial(mgy)}{\partial x} \quad = \quad 0$$

$$\text{Force in x dir} \quad = \quad -\frac{\partial(\text{PE})}{\partial x}$$

$$\text{Force in y dir} \quad = \quad -\frac{\partial(\text{PE})}{\partial y}$$

$$\text{Force in z dir} \quad = \quad -\frac{\partial(\text{PE})}{\partial z}$$

$$\text{SPE}(x) \quad = \quad \left(126 \; \frac{\text{J}}{\text{m}^2}\right) \; x^2$$

$$F_x \qquad - \; \frac{\partial(\text{SPE})}{\partial x}$$

$$F_x \quad = \quad -\left(126 \; \frac{\text{J}}{\text{m}^2}\right) \; 2x \quad = \quad -\left(252 \; \frac{\text{J}}{\text{m}}\right) x$$

$$\text{PE}(x) \quad = \quad 10\, x^2 \; \cos(x)\, e^{-x}$$