371.

Problem 31.40 (RHK)

We have to show that the plates of a parallel plate capacitor attract each other with a force given by

$$F = \frac{q^2}{2\varepsilon_0 A}.$$

Solution:

Let the separation between the plates of a capacitor, area *A*, be *x*. The capacitance of a parallel plate capacitor is

$$C = \frac{\varepsilon_0 A}{x}.$$

The electric energy of a capacitor is

$$U(x) = \frac{1}{2}CV^2 = \frac{q^2}{2C} = \frac{xq^2}{2\varepsilon_0 A}.$$

Therefore, energy of a capacitor having charge *q* when the separation between its plates is $x + \Delta x$ will be

$$U(x + \Delta x) = \frac{q^2(x + \Delta x)}{2\varepsilon_0 A}.$$

And,

$$U(x + \Delta x) - U(x) = \frac{q^2 \Delta x}{2\varepsilon_0 A}.$$

Therefore, an additional amount of work equal to $\frac{q^2 \Delta x}{2\varepsilon_0 A}$ will have to be done by some external agency in increasing the separation between the plates from x to $x + \Delta x$. This implies that plates of a charged parallel plate capacitor attract each other with a force

$$F = \frac{q^2}{2\varepsilon_0 A}.$$