369.

Problem 31.37 (RHK)

A parallel-plate capacitor has plates of area A and separation d and is charged to a potential difference V. The charging battery is then disconnected and the plates are pulled apart until their separation is 2d. We have to derive in terms of A, d, and V for (a) *the new potential difference,* (b) *the initial and final stored energy, and* (c) *the work required for separating the plates.*

Solution:

(a)

A parallel-plate capacitor has plates of area *A* and separation *d* and it is charged to a potential difference *V*. The capacitance of a parallel plate capacitor of plate area A and separation d is

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

As the capacitor is charged by connecting it to a battery of voltage *V*, the magnitude of the charge on the plates of the capacitor will be

$$q = CV = \frac{\varepsilon_0 A}{d} V.$$

Now the capacitor is disconnected from the battery. The plates of the capacitor are pulled apart until their separation is 2*d*. Now the capacitance of the capacitor will become

$$C' = \frac{\varepsilon_0 A}{2d}.$$

As the charge on the capacitor plates remains unchanged when its plates are separated, the potential difference across the plates will change to

$$V' = \frac{q}{C'} = 2V.$$

(b)

The stored energy in a capacitor of capacitance *C* with potential difference V is given by

$$U = \frac{1}{2} CV^2.$$

Therefore, the initial stored energy is

$$U_i = \frac{\varepsilon_0 A V^2}{2d},$$

and the final stored energy will be

$$U_f = \frac{1}{2} C' V'^2 = \frac{\varepsilon_0 A V^2}{d}.$$

(c)

The work required for separating the plates will be

$$W = U_f - U_i = \frac{\varepsilon_0 A V^2}{2d}.$$