1. **1 pt. for each answer (3pts. total)**
   a. Assuming the gap is constant, held at a constant voltage

   \[ F = \frac{1}{2} \varepsilon_0 V^2 \frac{A}{g^2} \]

   \[ V = \frac{Q}{C} \text{ so we get} \]

   \[ F = \frac{1}{2} \varepsilon_0 \frac{Q^2 A}{C^2 g^2} \]

   Also, \( C = \frac{\varepsilon_0 A}{g} \)

   \[ F = \frac{1}{2} \frac{Q^2}{C} \]

   b. For this case, \( E = \frac{V}{g} \)

   \[ F = \frac{1}{2} \varepsilon_0 A \left( \frac{V}{g} \right)^2 = \frac{1}{2} \varepsilon_0 A E^2 \]

   c. \( \frac{F}{A} = \frac{1}{2} \varepsilon_0 E^2 \)

2. **1 pt. for effort, 1 pt. for an approximately correct answer in each part (3 pts. total)**
   a. From question 1, we know the force in terms of the field

   \[ F = ma = \frac{1}{2} \varepsilon_0 A E^2 \]

   \[ E = \sqrt{\frac{m}{(\frac{\varepsilon_0}{C}) a}} \sqrt{\frac{1}{2} \varepsilon_0} \]

   \[ E = \sqrt{\frac{(1 \text{ kg/m}^2) (10 \text{ m/s}^2)}{\frac{1}{2} (10^{-11} \text{ F/m})}} = \sqrt{2 \times 10^{1+11}} \]

   \[ E = 1.4 \text{MV/m} \]
b. For a parallel plate

\[ \frac{V}{g} = E \]

\[ V = \left(1.4 \frac{\text{MV}}{\text{m}}\right)(100 \times 10^{-6}\text{m}) \]

\[ V = 140\text{V} \]

3. 1 pt. for effort, 1 pt. for each approximately correct part (3 pts. total)

a. 

\[ F = \frac{1}{2} \epsilon_0 V^2 \frac{A}{d^2} = mg \]

\[ A = \frac{mgd^2}{\frac{1}{2} \epsilon_0 V^2} \]

\[ A = \frac{(50\text{kg}) \left(10 \frac{\text{m}}{\text{s}^2}\right)(10^{-6}\text{m})^2}{(10^{-7}\text{N})} \]

\[ A = 5 \times 10^{2-12+7} \frac{\text{Nm}^2}{\text{N}} \]

\[ A = 0.005\text{m}^2 \]

This is a 7 cm x 7 cm plate

a. 

\[ A = \frac{(50\text{kg}) \left(10 \frac{\text{m}}{\text{s}^2}\right)(10^{-5}\text{m})^2}{(10^{-11}\text{N})} \]

\[ A = 5 \times 10^{2-10+11} \]

\[ A = 5000\text{m}^2 \]

A 70 m x 70 m plate. For the larger gap and smaller voltage, the area is \textbf{10^6 times larger}. For parallel plates, \( E = \frac{V}{d'} \) so the field is \textbf{10^3 times weaker}. For the answer to part b. This makes sense, since the force is
related to $E^2$ so a change in $E$ would require a change in $A^2$ to maintain the same force.

4. 1 pt. for each correct label in part a., 1 pt. for part b. (4pts. total)

a.

b. 42 finger gaps for each differential cap, finger length is about 100µm, device layer 2µm

\[ C(0) = \frac{N\varepsilon_0 A}{d} \]

\[ = \frac{(42)(10^{-11} \text{ F/m})(2\times10^{-6} \text{ m})(10^{-4} \text{ m})}{1.2\times10^{-6} \text{ m}} \]

\[ = 70 \text{ fF} \]
5. **1 pt. for part a, 1 pt. for each correct label in part b (7pts. total)**

   a. Using the scale bar, and measuring around the mass, with a 2µm device layer, I get approximately a **70ng mass**.

   b.

6. **1 pt.**
   The wet etch should undercut the photoresist

7. **1 pt. for each correct part (6 pts. total)**
   a. Substrate, nitride, poly0, oxide1, poly1, oxide2, poly2
   b. Substrate, nitride, poly0, poly1, poly2
   c. Substrate, nitride, poly1, oxide2
   d. Substrate, nitride, oxide1, oxide2, poly2, metal
   e. Substrate, nitride, oxide1, oxide2, metal
   f. Substrate, nitride, oxide1, oxide2
8. 1 pt. for a correct final cross section
   1 pt. for the dimple under poly1
   1 pt. for metal contacting poly2
   1 pt. for having poly2 contact poly1 and poly0

9. 5pts. for appropriate effort