Physics 222
Opportunity I

Make sure your name and social security are on all pages of your test. **Show all work clearly!!!!** The question is wrong if all work is not clearly shown. It is your responsibility to make sure you understand the question before attempting it. "Cheating" is unfair to those who work for their grade, so if you work for your grade I encourage you to let me know if you see anyone cheating. Be sure to look on the back of the test. Assume ideal conditions unless otherwise stated. Label things clearly. The final answer must include units where appropriate.

Some useful values: \( \varepsilon_0 = 8.85 \times 10^{-12} \text{ F/m} \), \( e = 1.6 \times 10^{-19} \text{ C} \), \( m_e = 9.11 \times 10^{-31} \text{ kg} \).

1) Homer Simpson is setting in his favorite couch, watching television, and a question comes to his mind. How fast are the electrons traveling when they impact on the back of the picture tube? Assume that the electrons are accelerated across a electric potential of 30,000 volts. Ignore relativistic effects.

2) As usual, Christian disassembled his most recent toy. It has a cylindrical shape that consists of two coaxial cylinders separated by air. The inner and outer cylinders are conductors. The toy has a length \( L \). The inner conductor has a radius of \( a \) and the outer conductor has an inner radius of \( b \) and an outer radius of \( c \). The inner conductor has a net positive charge of \( +Q \) on it. The outer conductor has a net negative charge of \( -Q \) on it. Note that the charges are equal in magnitude and opposite in sign. Assume \( L \gg c \). The natural curiosity of any three year old lead Christian to ask the following questions. Express your answer in terms of standard constants and the parameters and variables given in the problem where appropriate. \( a, b, c, L, Q \) and \( r \). **Show all work and/or clearly explain your answer!**

a) What is the electric field just outside the outer conductor \( (r > c) \)?

b) What is the electric field inside the outer conductor \( (b > r > c) \)?

c) What is the electric field in the region between the two conductors \( (b > r > a) \)?

d) What is the electric field inside the inner conductor \( (a > r) \)?
3) The toy that Christian took apart in the previous problem is a cylindrical capacitor. Calculate the capacitance in terms of the given parameters.

4) Two capacitors and a 12 volt battery are all connected in series. The capacitance of one of the capacitors is 3 \( \mu F \) and the capacitance of the other is 5\( \mu F \). What is the charge on the 3 \( \mu F \) capacitor?

5) Four charges are arranged in a square pattern which is 7 meters on an edge, as shown in the accompanying figure. \( q_1 = +2C, q_2 = +1C, q_3 = -1C, q_4 = -3C \).
   a) What is the electric field at the center of the charge distribution? Give the magnitude and indicate the direction on the figure.
   b) At what point, inside the square, is the electric field equal to zero? Clearly indicated the position in terms of the given x & y coordinate system.