1. Consider the following spacecraft geometry,

An oxygen ion is formed in the vicinity of two experimental buses of a small satellite. The oxygen ion has an initial velocity in the x-direction only and an energy of 20 eV. The experimental buses have a potential difference of 20 Volts from a combination of voltage leaks from the instruments and differential spacecraft charging. The ion’s initial position is exactly half way between the metallic plates enclosing the experimental instruments. The metallic plates are 15.24 cm long and separated by a distance of 12.7 cm.

a.) Derive the equations of motion for the ion as a function of time (i.e. x(t) and y(t)) from the Lorentz force equation. Find the solution for the y positon independent of time. 
**Hint:** Determine the initial conditions for the problem (i.e. at some time \( t_0 = 0 \)) and apply these to the differential equations. Assume that no fringing fields are present.

b.) Calculate and plot the ion’s trajectory through the region between the plates.

c.) Determine the ion trajectory outside the plates.
d.) Will the ion strike the solar panel, and if so, where will the ion strike? (i.e. the x position of the impact).

e.) What can be done before launch to ensure that such a contamination event does not occur?

(Hints: For ease of calculation, use the coordinate system provided. You will need to solve the differential equations set up by the Lorentz force equation discussed in class for the x, y positions as a function of time. Before setting out to solve the Lorentz force equation, establish the initial conditions of the problem. Writing a simple FORTRAN or MATLAB code is probably the easiest way to solve the equations of motion for small time/distance steps. The magnitude of the electric field is \( E = \Delta V / h \) where \( h \) is the separation distance of the parallel plates. The direction of the electric field is left up to the student to decide.)

2. In 2012, the US Air Force will launch the Space Based Infrared (SBIR) satellite system into orbit. You have been given the job of chief environmental interaction engineer. The mission designers have indicated that the SBIR satellite will be in a nearly circular orbit with an altitude of approximately 400 km. The mission is to last 10 years with a 65% operational status. The material engineers have identified a Teflon™ surface as the major contamination source to the infrared (IR) detector. The Teflon surface is a rectangular piece with a length of 3 cm and a width of 2 cm; it has a temperature of 300 K and a mass of 10.0 grams. The circular IR sensor has a radius of 0.25 meters and is cryogenically cooled at 100 K. The major outgassed species is the Teflon monomer (C\(_2\)F\(_4\)) with an activation energy of 10 kcal/mol.

a.) Calculate the number flux (molecules/sec) impacting the IR surface for the geometry given below assuming the Teflon surface meets the ASTM E 595 standard.

b.) Calculate the average residence time of the Teflon monomer on the IR sensor.

c.) Assuming the Teflon monomer is a hard sphere with a diameter of 7 Å. Calculate the time required for a monolayer of C\(_2\)F\(_4\) to be adsorbed on the IR surface assuming a sticking coefficient, \( s = 0.5 \).

3. List at least two mechanisms by which the accommodation coefficients for a spacecraft
material can change due to the vacuum environment. How might these changes be avoided or minimized? Why does the rate of change in the accommodation coefficient decrease with satellite lifetime?

4. An orbiting tactical communications satellite is in thermal equilibrium at 25° C. Assume the communications satellite is spherical, has a radius of 2.0 m and a uniform emissivity of 0.8. The US Air Force intends to track the satellite and blow it from the heavens with a sophisticated laser system on-board a surveillance satellite. The surveillance satellite is 5,000 km from the communications satellite and both are orbiting at a GEO altitude.

a.) Calculate the wavelength at which the communications satellite radiates most of its energy. This is the wavelength of most interest to the surveillance equipment on board the US spacecraft.

b.) Estimate the number of photons emitted per second by the communications satellite (at the wavelength identified in part a) which reach the US surveillance satellite.

c.) The radiation of unburnt hydrazine due to interactions with atomic oxygen is known to be orders of magnitude more intense than the IR radiation from the spacecraft emission. If the communications satellite uses hydrazine thrusters for attitude control, would it make more sense to observe the radiation which arises due to the interactions between unburnt hydrazine in the plume and atomic oxygen? Explain. (Assume that there is time to wait for a thruster firing to occur and that the wavelength of the radiation is unimportant to the surveillance satellite.)