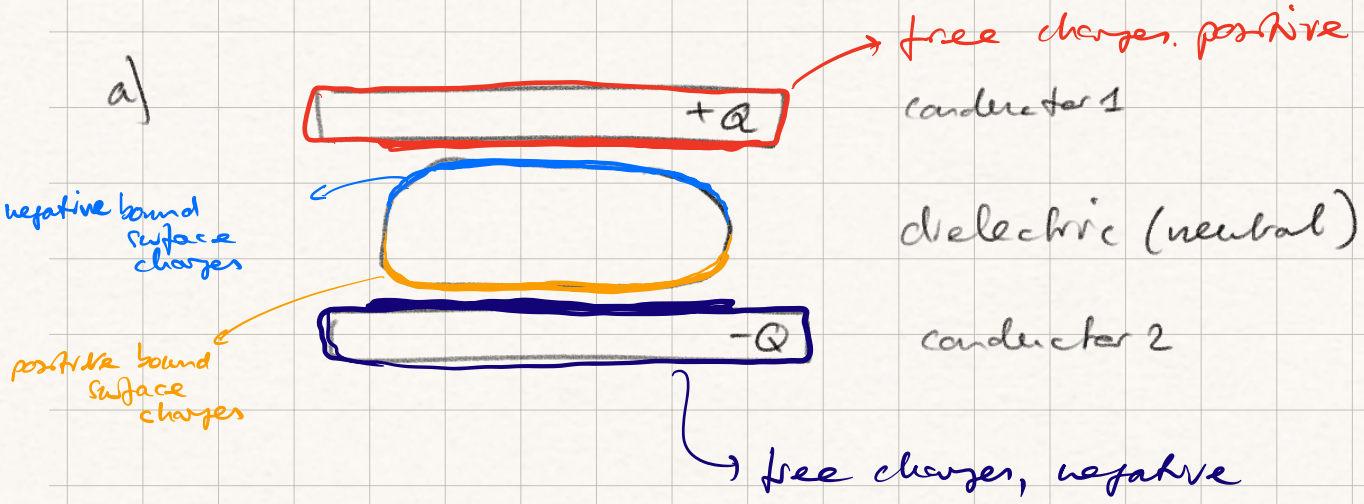
Sketch for E&M test 2 2023 Question 5

a)



Points:

1/2 - Positive free charges on the +Q potential, negative on -Q.

1/2 - Bound surface charges on dielectric, reversed orientation compared to free charges.

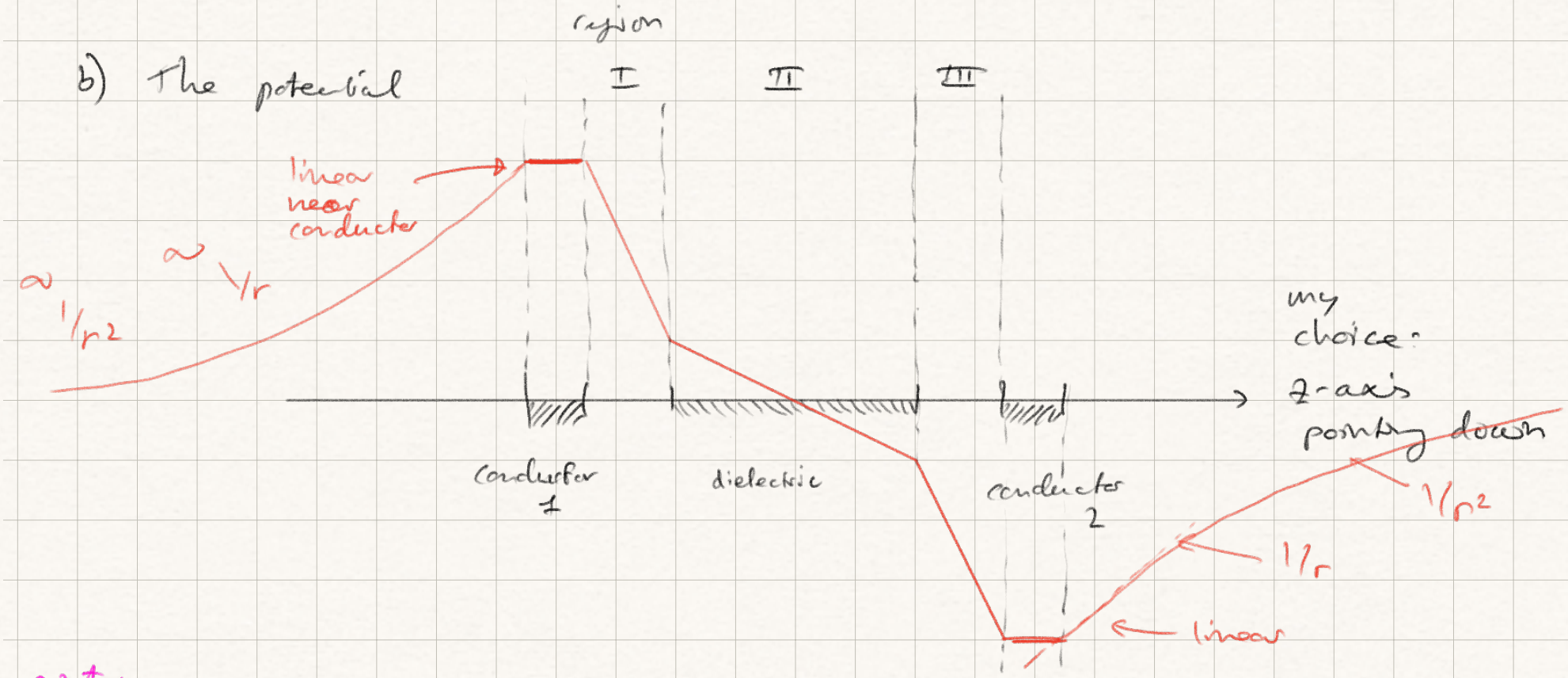
1 - Free & bound charges are both only on the surface of the conductor & dielectric.

1/2 - There are more free surface charges on the conductors where they are close to the dielectric

1/2 - The surface bound charges are mostly on the top & bottom - but also a bit on the curved sides.

3

b) The potential



points:

1 – Conductors are equipotential (V = constant, + for conductor 1, – for conductor 2)

1 – linear slope on z-axis in regions I, II, III.

1 – reduced slope in region II; result of polarization of dielectric.

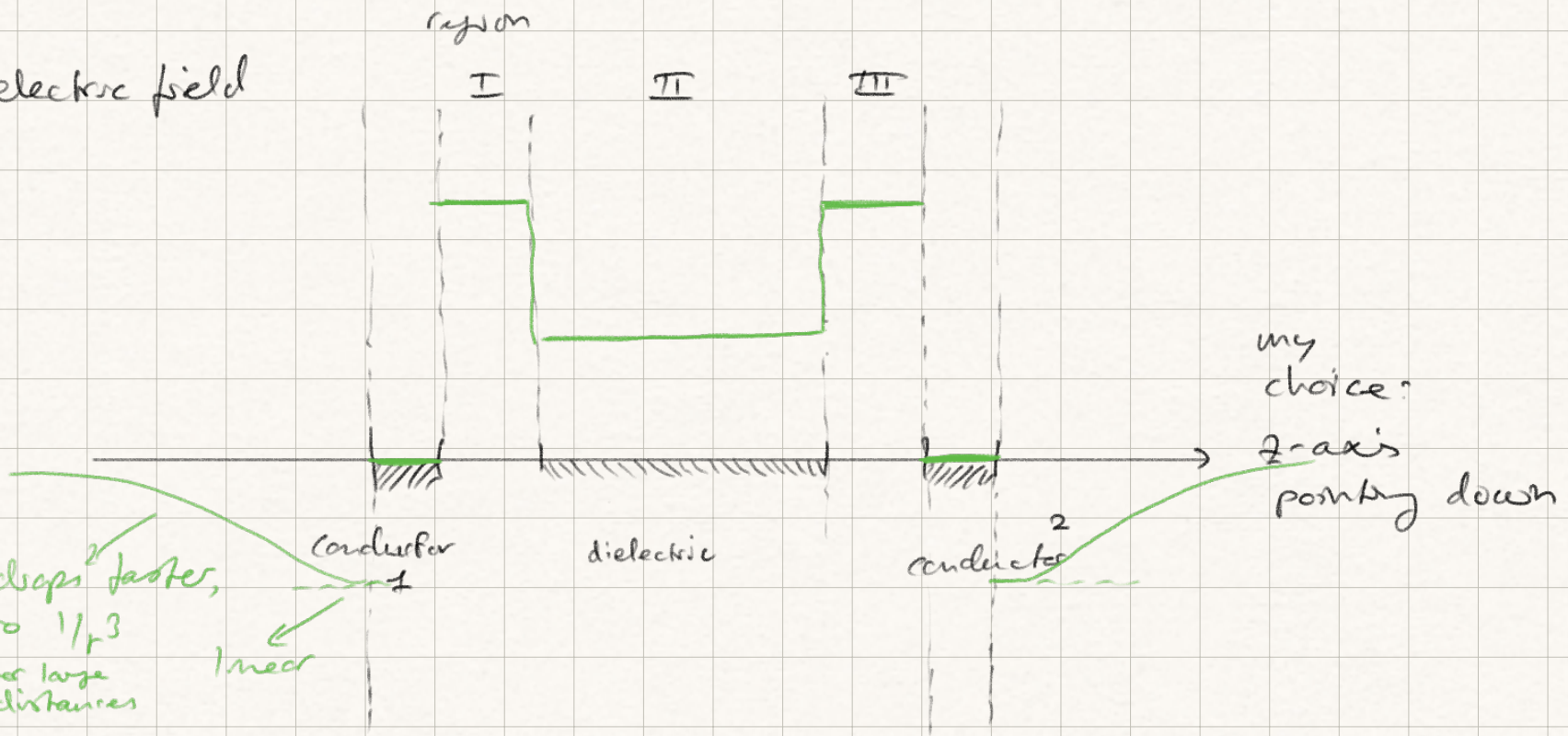
1/2 – also linear just above conductor 1 and below conductor 2 ($\vec{E}$ constant)

1/2 but with slope reduced compared to inside of capacitor.

1 – Further away from plates: first $\propto 1/r$, then $\propto 1/r^2$, because like a dipole.

5

c) The electric field



points:

1 - zero $\vec{E}$ inside the conductors

1 - constant high field between conductors & dielectric, reduced (but same sign) inside the dielectric

1/2 - linear above conductor 1 and below conductor 2,

1/2 at reduced magnitude compared to side where dielectric is.

1 - further away from conductors: transition to $1/r^3$ (dipole).

1 - sign correct with respect to potential $\vec{E} = -\vec{\nabla} V$

1/5

d) As the dielectric is removed, the electric field between the conductors is no longer reduced due to the polarization of this material. Therefore, the electric field increases. One can also say that by removing the dielectric the capacitance, $C = \frac{Q}{V}$, is reduced; as charge is constant this means that the voltage (= the potential difference) is increased between the plates, and therefore the electric field is also increased.

3 points for complete explanation.