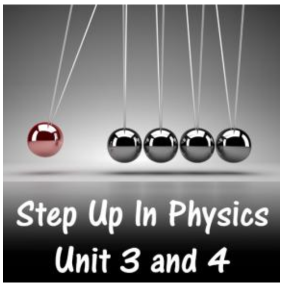
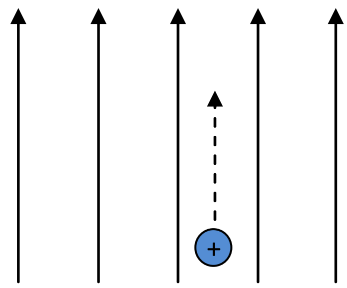
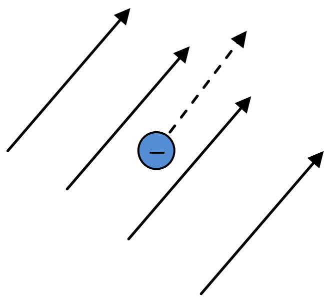
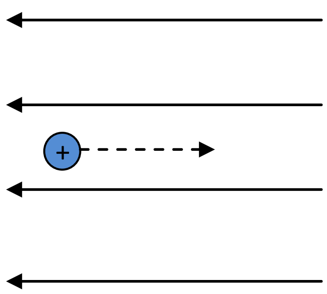
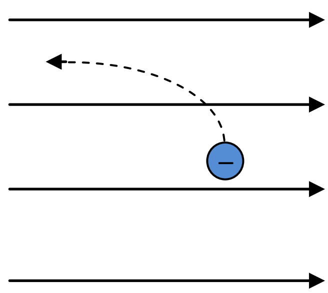
Work and Energy in an Electric Field

Problems Worksheet

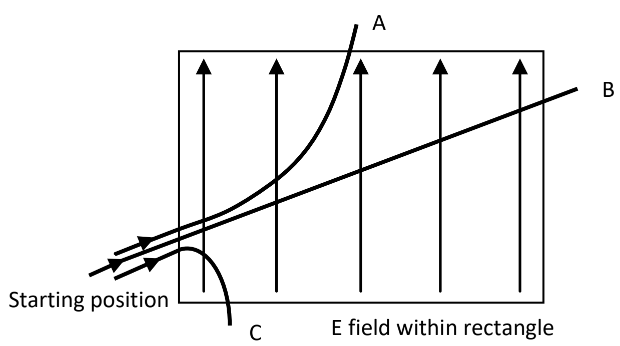


1. Calculate the work done by an electric field established by a 1650 V potential difference when a single electron moves through the field.

2. The following scenarios show charged particles moving (dashed arrows) through electric fields (solid arrows). Indicate, by circling the correct option for each scenario, whether work has been done **by** the electric field or work has been done **on** the electric field.

 Done on field/ Done by field	 Done on field/ Done by field
 Done on field/ Done by field	 Done on field/ Done by field

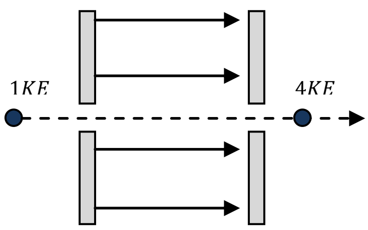
3. Three particles of identical mass move into an electric field at the same initial velocity. The path each particle followed is shown in the diagram below. Based on the path each particle took, describe the differences between the charge of particle A, B and C.



4. A 9.40 × 10^{-5} kg drop of oil has a 6.22 × 10^{-9} C charge and is sitting at rest. A 16.0 NC^{-1} electric field is established around the oil drop.
    a. Calculate the kinetic energy of the oil drop after the drop had displaced 5.00 cm through the field.
    b. Explain how the increase in kinetic energy of the oil drop does not contradict the law of conservation of energy.
    c. Calculate the potential difference the drop moved through after displacing 5.00 cm.

5. A charged dust particle, starting from rest, moves 1.20 m against a 3.00 NC^{-1} uniform electric field.
    a. Is the charge of the dust particle positive or negative? Justify your response.
    b. Calculate the potential difference the dust particle moved through.

6. A charged oil drop is moving with a kinetic energy of $1KE$ when it enters a uniform electric field. After exiting the field it had a kinetic energy of $4KE$.



    a. Explain why the oil drop experienced a change in kinetic energy.

b. A similar oil drop enters the field with an initial kinetic energy of $2KE$. Determine, in terms of KE, the final kinetic energy of this oil drop.

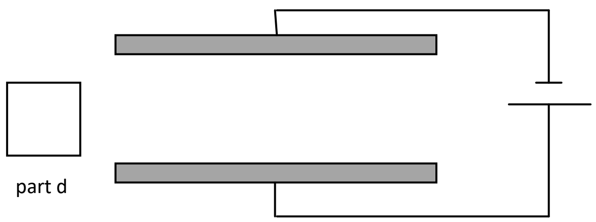
c. The electric field strength is doubled. A similar oil drop enters the field with an initial kinetic energy of $1KE$. Determine, in terms of KE, the final kinetic energy of this oil drop.

7. A single electron is accelerated by an 8.50 NC^{-1} electric field. How far would the electron have moved when the field has done 2.72 eV of work on the electron?

The following questions may require knowledge covered in Gravity and Motion.

8. Two parallel plates are separated by 28.0 cm with a 50.0 V potential difference across them.

a. Draw the electric field between the two plates



b. Calculate the strength of the electric field.

c. Calculate the force that would be applied to an electron inside this field.

d. In the box provided near the diagram, draw the direction an electron would move if placed inside this field.

e. Calculate how long it would take an electron, starting from rest at one plate, to reach the plate on the far side.

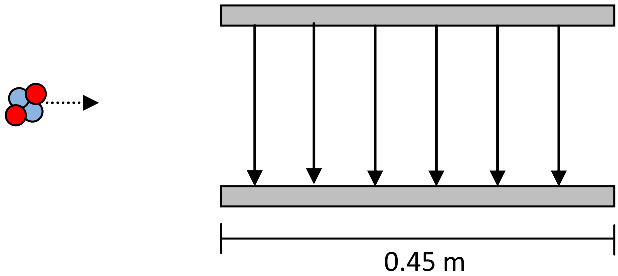
9. An X-ray generator relies on high speed electrons striking a metal target to produce EMR in the X-ray portion of the spectrum. Electrons are accelerated using a linear accelerator (linac) which uses electric fields to do work on the electrons, giving them energies of up to 10 keV.
   a. Calculate the kinetic energy in Joules of the electrons as they strike the metal target.

   b. The electric field accelerates the electrons over a distance of 1.20 m. What strength electric field is required to produce a 10 keV electron beam?

   c. A linac can also accelerate other particles. Describe any changes you could make to the electric field (direction and strength) inside the X-ray generator's linac so a proton beam travels in the same direction and attains the same energy as the electron beam.

   d. Describe any changes you could make to the electric field (direction and strength) so that a beam of neutrons could be accelerated by the electric field.

10. An alpha particle (helium nucleus of mass 6.64×10^{-27} kg and 2+ atomic charge) is fired perpendicularly across an electric field produce by parallel plates separated by a distance of 30.0 cm as shown in the diagram below. The electric field is 0.450 m wide and has a uniform strength of 6.00 NC^{-1}. The alpha particle is initially moving at a speed of 1.52×10^{4} ms^{-1} and is half way between the two plates when it enters the field.



a. How long would it take the alpha particle to exit the field once it enters?

b. Calculate the vertical displacement of the alpha particle after it exits the field.

c. Draw the path of the alpha particle as it passes through the field in the diagram above.

d. Calculate the amount of work the field does on the alpha particle.

e. What is the maximum field strength that can deflect the alpha particle without it hitting either plate?

