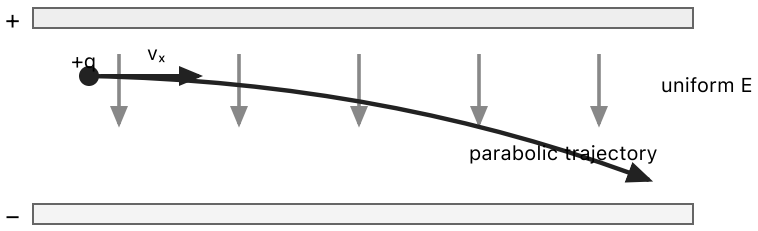
ELECTRICITY DAY 9: UNIFORM FIELDS & PARALLEL PLATES

CED 10.3 · Skill 2.B · FRQ: MR · target: the ideal plate field is uniform, not stronger near one plate

PREDICT FROM THE PRINTED SETUP

A positive particle enters the central region between parallel plates with horizontal velocity. The upper plate is positive and the lower plate negative. Circle the path: **straight / parabolic / circular / spiral**. Draw the initial force direction.

CHARGED PARTICLE BETWEEN IDEAL PARALLEL PLATES



THE IDEAL PLATE FIELD

Away from the edges, two large oppositely charged plates produce a field with nearly constant magnitude and direction. Field arrows are parallel and equal in length. The model omits edge fringing.

QUICK Compare E at three points along the centerline between the plates. Then state what changes near the plate edges.

FORCE AND ACCELERATION

$$\vec{F} = q\vec{E} \qquad \vec{a} = \frac{q\vec{E}}{m}$$

For positive q, force and acceleration point with E. For negative q, they point opposite E.

WE DO A $+3.0\text{nC}$, $1.20 \times 10^{-6}\text{kg}$ particle enters a downward 2400N/C field at $v_x = 12\text{m/s}$. The plates are 0.24m long. Find (a) force, (b) acceleration, (c) time between plates, and (d) vertical deflection.

DIRECTION CHECK Repeat only the force and acceleration directions if the particle's charge is negative.

PROJECTILE ANALOGY

Horizontal

No electric-force component:

$v_x = \text{constant}$

$t = L/v_x$

Vertical

Constant electric acceleration:

$a_y = qE_y/m$

$\Delta y = v_{y0}t + \frac{1}{2}a_y t^2$

YOU DO A -2.4nC, $1.50 \times 10^{-6}\text{kg}$ particle enters a 3500N/C upward field at 10m/s. Plate length is 0.20m. Find the acceleration and deflection, including direction.

Representation check: the trajectory curves toward the force direction. Velocity remains tangent to the path; it is not the same vector as force.

PRACTICE

1. Find the force on $+4.2\text{nC}$ in a $1.80 \times 10^{4}\text{N/C}$ field directed east.

2. A -3.5nC, $2.0 \times 10^{-6}\text{kg}$ drop is in a $6.0 \times 10^{3}\text{N/C}$ downward field. Find acceleration magnitude and direction.

3. A positive particle crosses 0.30m-long plates at 15m/s. Its vertical acceleration is 8.0m/s^2. Find deflection.

4. State two conditions under which the ideal uniform-field/parabolic-path model becomes less accurate.