# Electric Field

- More continuous charge distributions
- Electric Field Lines
- Motion of charged particles

Text 23.6, 23.7

Practice:
Chapter 23,
Objective Question 13
Problems 39, 43, 49, 57, 63

- Field of several point charges $q_i$:

$$\vec{E} = \sum_i k_e \frac{q_i}{r_i^2} \hat{r}_i$$

- Field of continuous charge distribution:

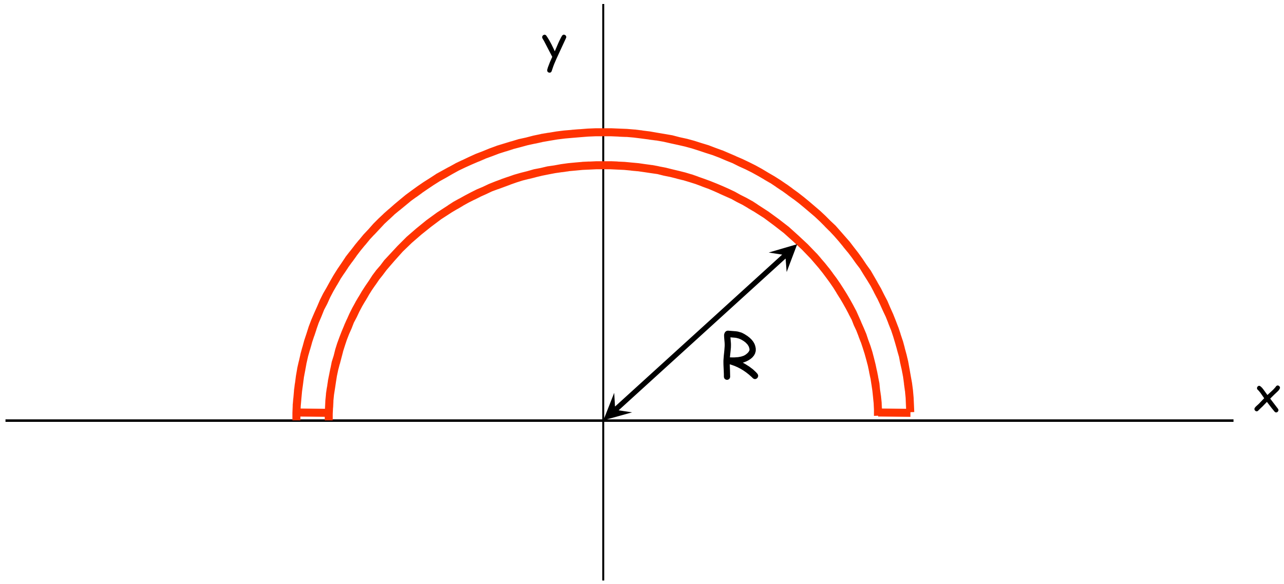
$$\vec{E} = \int k_e \frac{dq}{r^2} \hat{r}$$

In 2D problems, integrate components separately:

$$E_x = \int dE_x = \int k \frac{dq}{r^2} \underbrace{(\cos\theta)}_{\text{x-component of } \hat{\mathbf{r}}}$$

$$E_y = \int dE_y = \ldots\ldots$$

# Example: Uniformly-Charged Semicircle

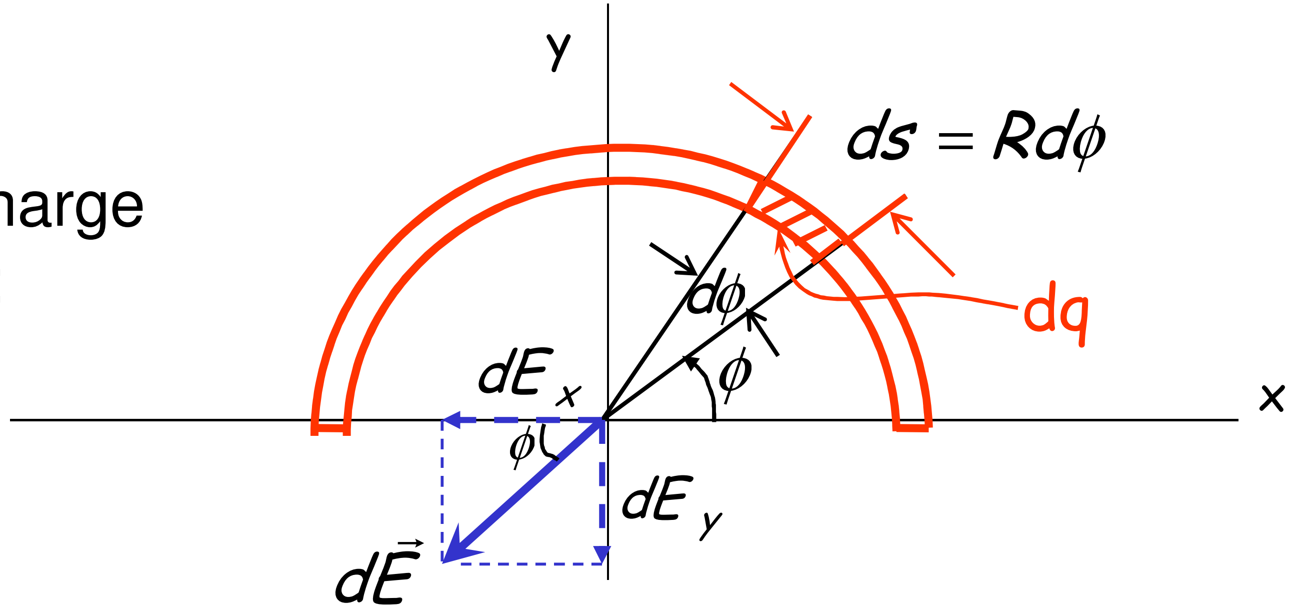



Charge/unit length, $\lambda$ , is uniform

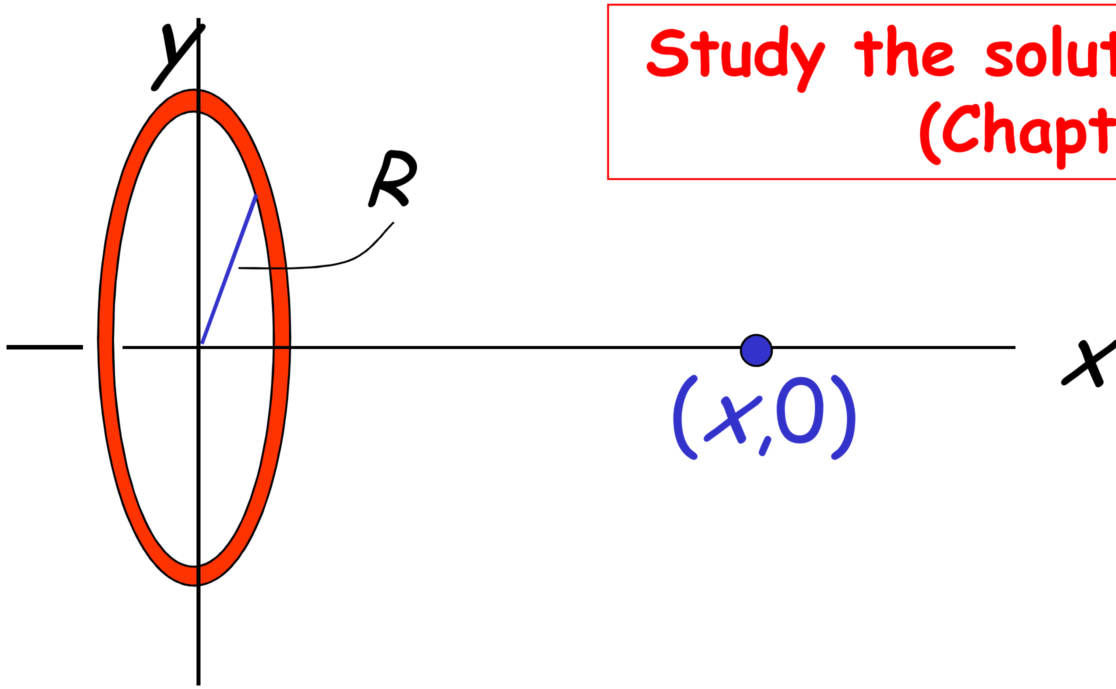
Find: $\vec{E}$ at origin

## Solution:

1) **dE** of charge element *dq*:



# Exercise: Uniformly-Charged Ring




Study the solution in the text (Chapter 23)

Total charge Q, uniform charge/unit length, radius R

Find: **E** at any point ($x$, 0) on the axis of the ring

# Electric Field Lines

Electric field lines are a way of visualising the field.

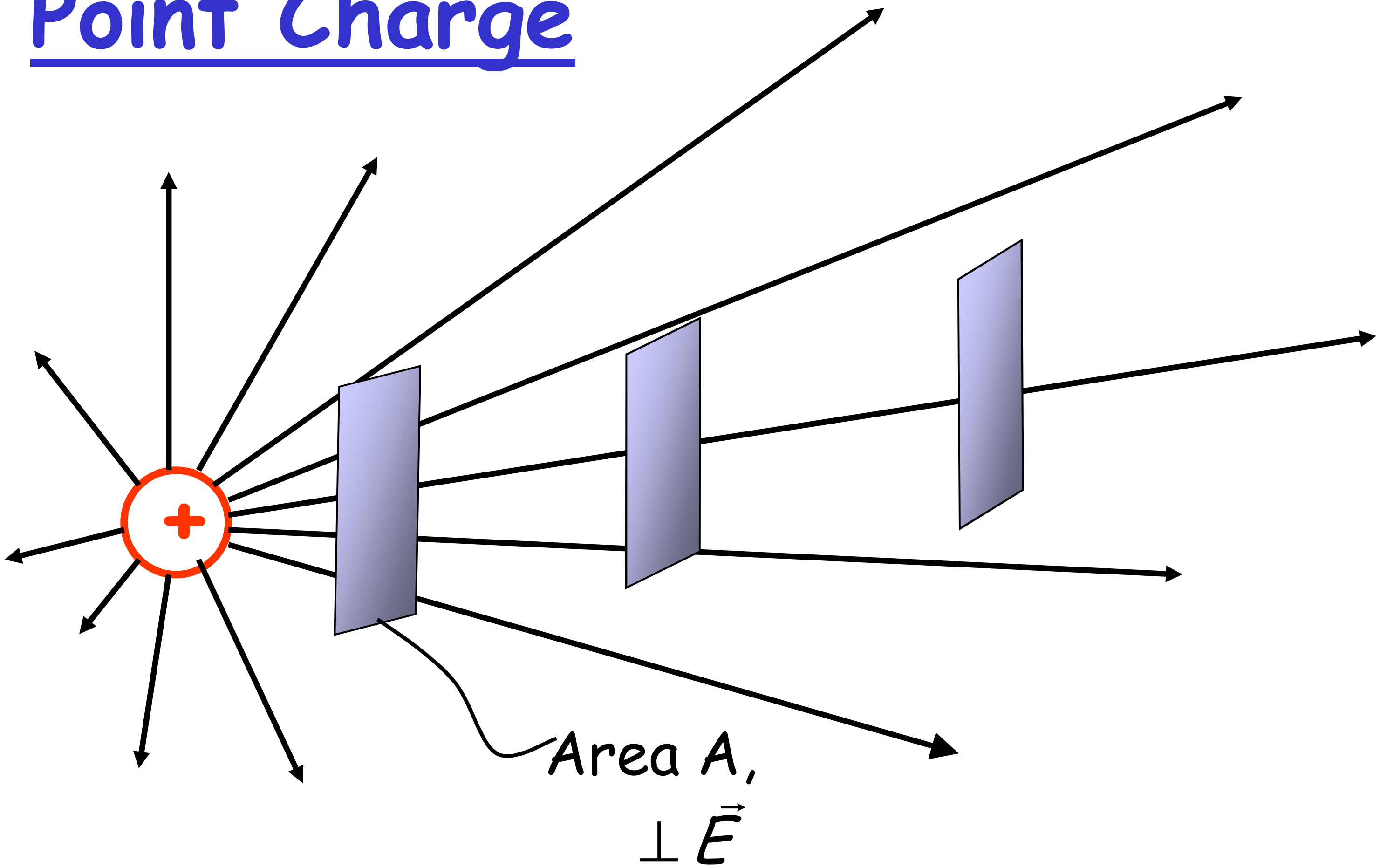
**Rules for Drawing:**

1) Lines *start* on (+) charges, *end* on (-) charges
2) (# of lines) $\propto$ charge
3) Lines never cross

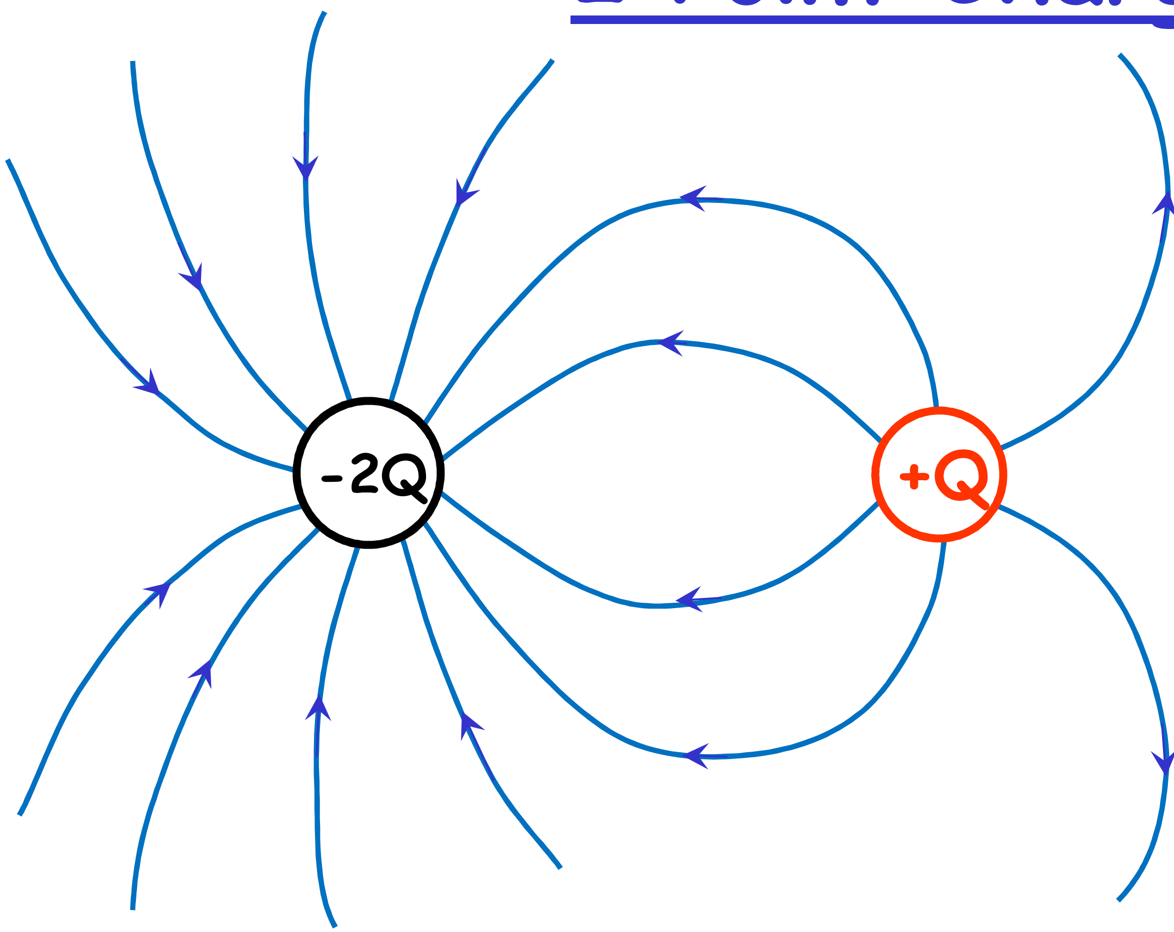
**Interpreting the picture:**

- $\vec{E}$ is *parallel* to the field line at each point.
- $\left|\vec{E}\right| \propto \left( \text{number of lines} \middle/ \text{unit area} \right)$

# Point Charge



# 2 Point Charges

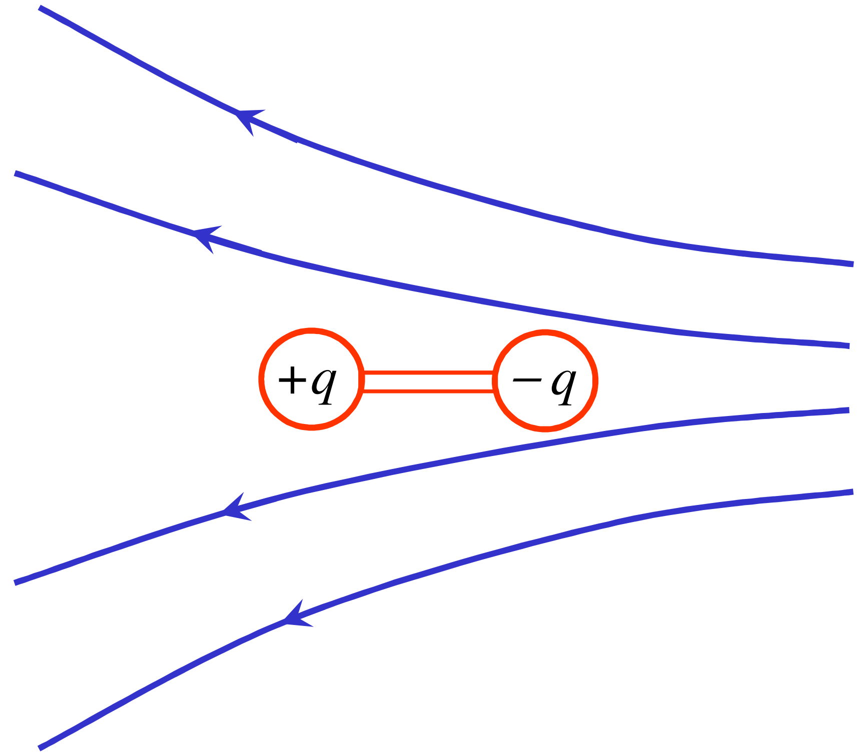



**Note:**

• number of lines is twice as many on -2Q

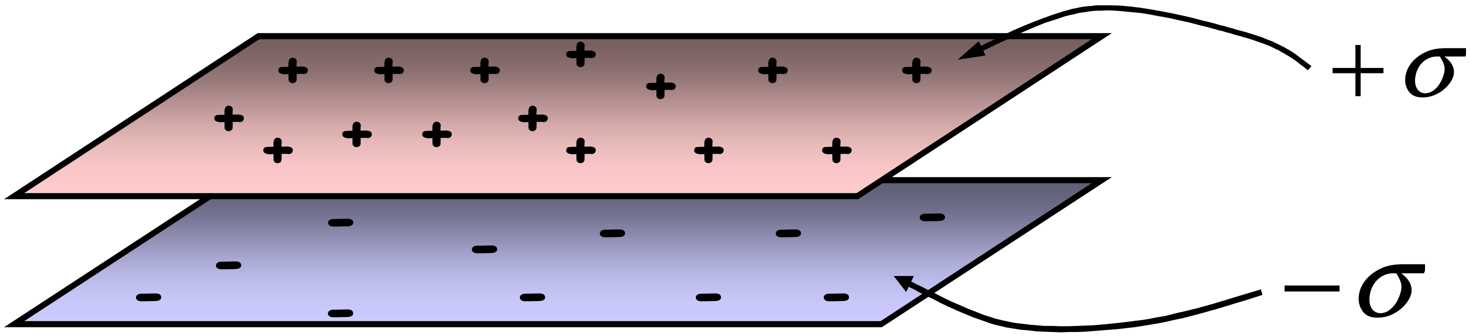
# Quiz:

*Which way will the dipole start to move in the electric field shown?*




A) up ↑
B) down ↓
C) left ←
D) right →
E) nowhere - there is no net force.

# Parallel Charged Plates




$$\sigma = \frac{\text{charge}}{\text{unit area}}; \quad \text{uniform}$$

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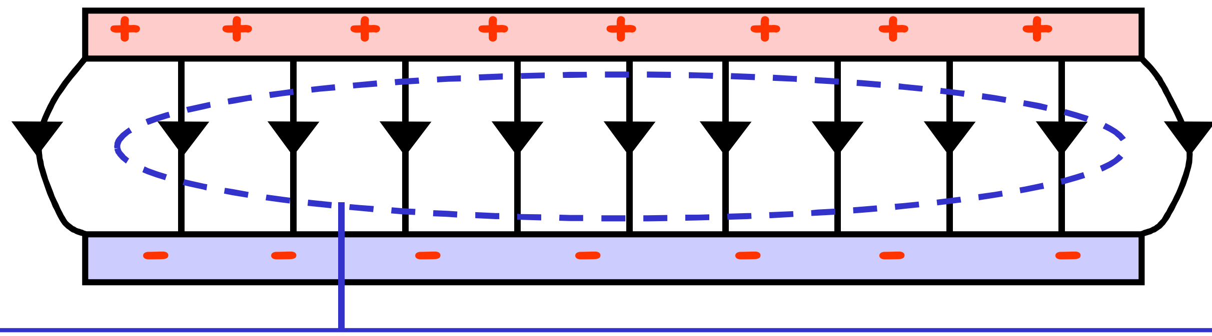
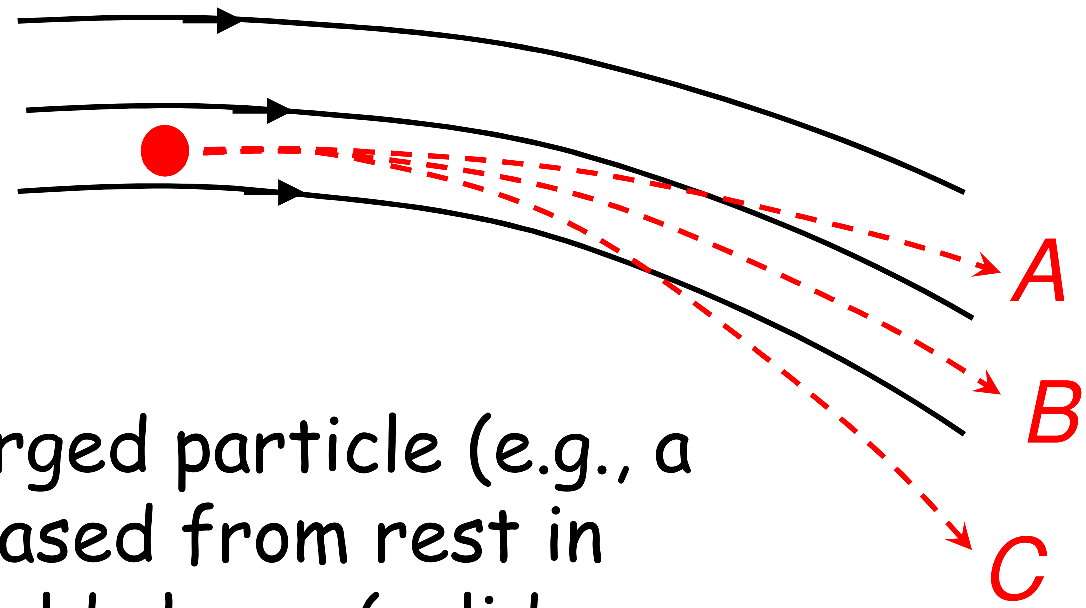



$\mathbf{E}$ approx. uniform, $\perp$ plates, except near the ends.

## QUIZ:




A positive charged particle (e.g., a proton) is released from rest in the electric field shown (solid black lines).

Which path will it follow?

# Motion of a charged particle

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

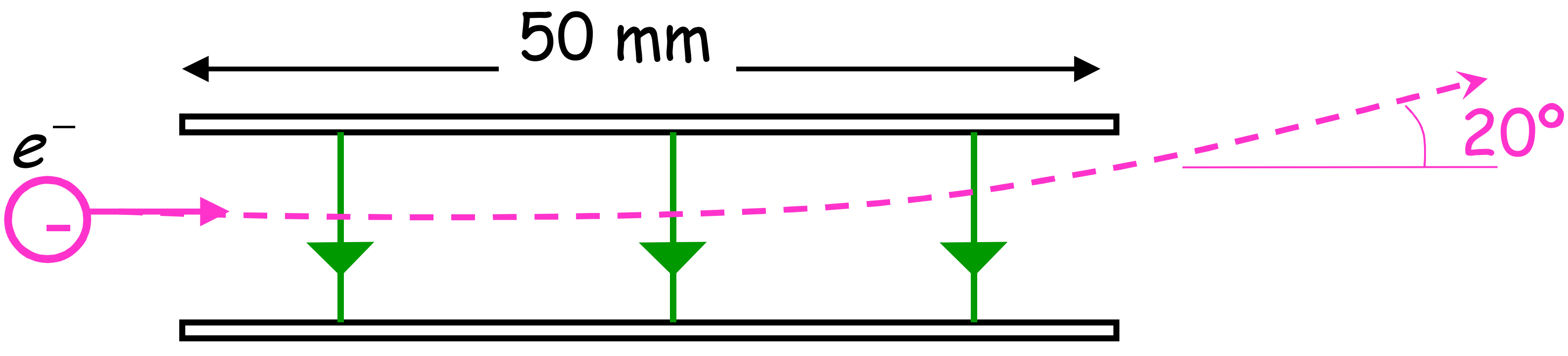
$$i.e: \quad \vec{a} = \frac{q}{m}\vec{E}$$

If **E** is *uniform*, **a** is constant

$\Rightarrow$ familiar kinematics

(but in general **E** is *not* uniform - check first!)

# Example: Uniform E




$v_o = 10^7 \, m/s$

Find: $\vec{E}$ between plates to get a 20° deflection.