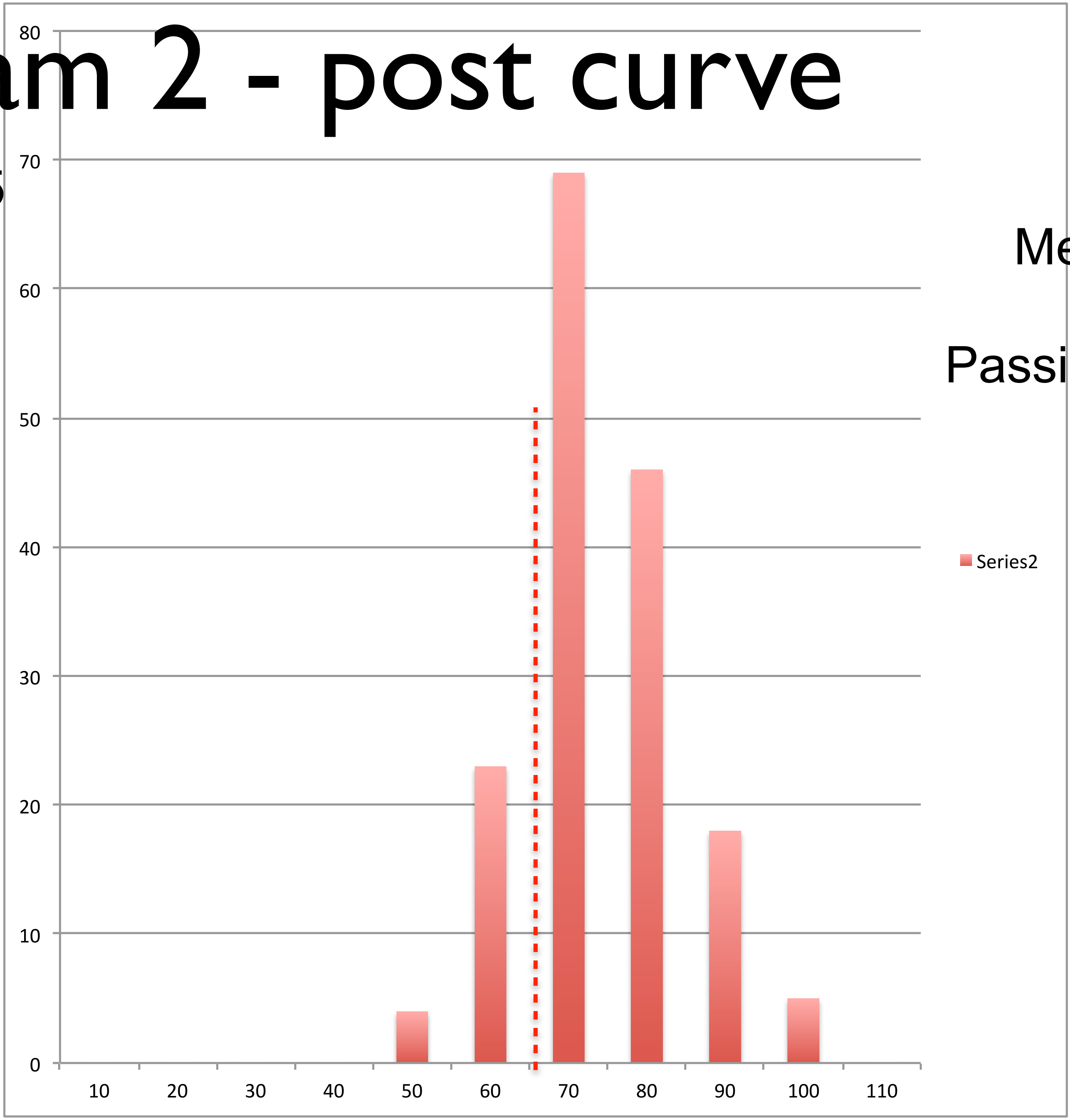
Lecture 22

PHYC 161 Fall 2016

Exam 2 - post curve

N=165



Mean = 70

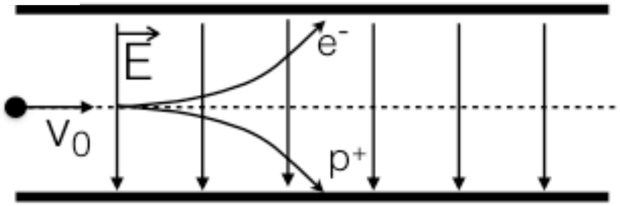
Passing >=63

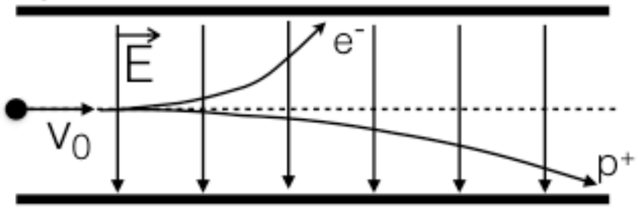
Extra Credit Written HW
DUE 10/24/16

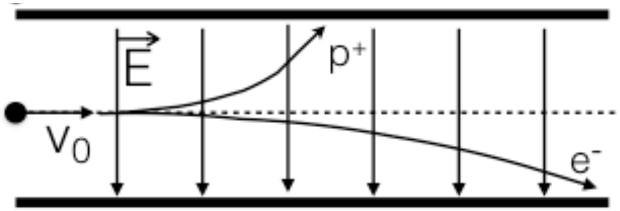
Write out a detailed solution for EACH of the following four from Exam 2. IF YOU GOT ANY of these problems correct, you do not have to redo — please indicate this in your write-up and include your exam paper (or copy) when you turn it in.

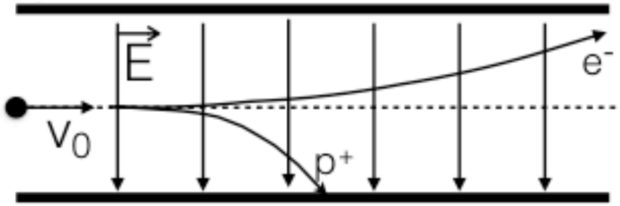
5 pts each, total 20 possible extra credit points

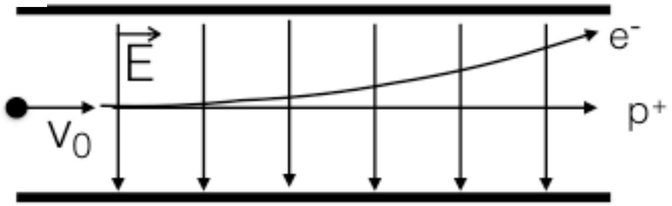
EC Q1. An **electron and a proton** are sent with **identical initial velocities, v_0**, into a region containing a **uniform electric field, E**. Which of the following diagrams correctly shows the trajectories of the particles?











Choices are different for TestID AA and BB

EC Q2 The indicated **positive and negative charge densities** are placed in **infinite sneets** and arranged as shown in the figure below. What is the **magnitude and direction** of the **electric field** in each of the 4 regions, E_1, E_2, E_3, E_4? ¶

¶

A. $E_1=\frac{\sigma}{2\varepsilon_0}\hat{x}$, $E_2=\frac{\sigma}{2\varepsilon_0}\hat{x}$, $E_3=\frac{\sigma}{\varepsilon_0}\hat{x}$, $E_4=\frac{\sigma}{2\varepsilon_0}\hat{x}$ ¶

B. $E_1=\frac{-\sigma}{\varepsilon_0}\hat{x}$, $E_2=\frac{\sigma}{\varepsilon_0}\hat{x}$, $E_3=0$, $E_4=\frac{\sigma}{\varepsilon_0}\hat{x}$ ¶

C. $E_1=\frac{-\sigma}{2\varepsilon_0}\hat{x}$, $E_2=\frac{\sigma}{2\varepsilon_0}\hat{x}$, $E_3=0$, $E_4=\frac{\sigma}{2\varepsilon_0}\hat{x}$ ¶

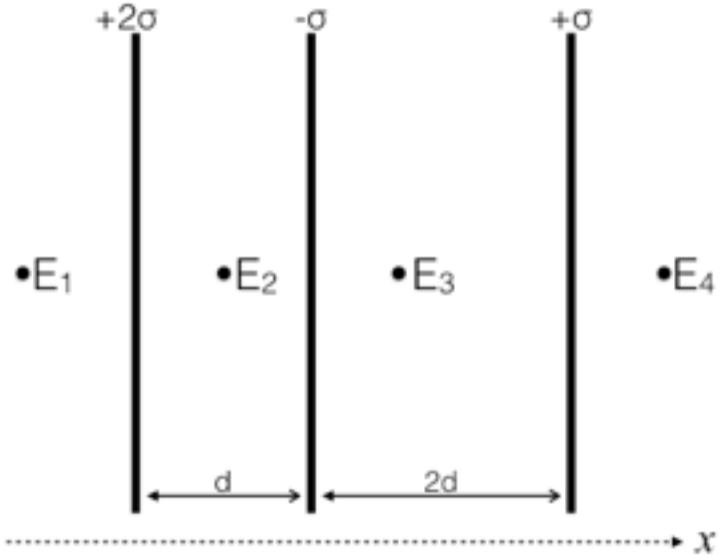
D. $E_1=\frac{\sigma}{2\varepsilon_0}\hat{x}$, $E_2=\frac{\sigma}{2\varepsilon_0}\hat{x}$, $E_3=\frac{-\sigma}{\varepsilon_0}\hat{x}$, $E_4=0$ ¶

E. Cant answer – it depends on *d* ¶

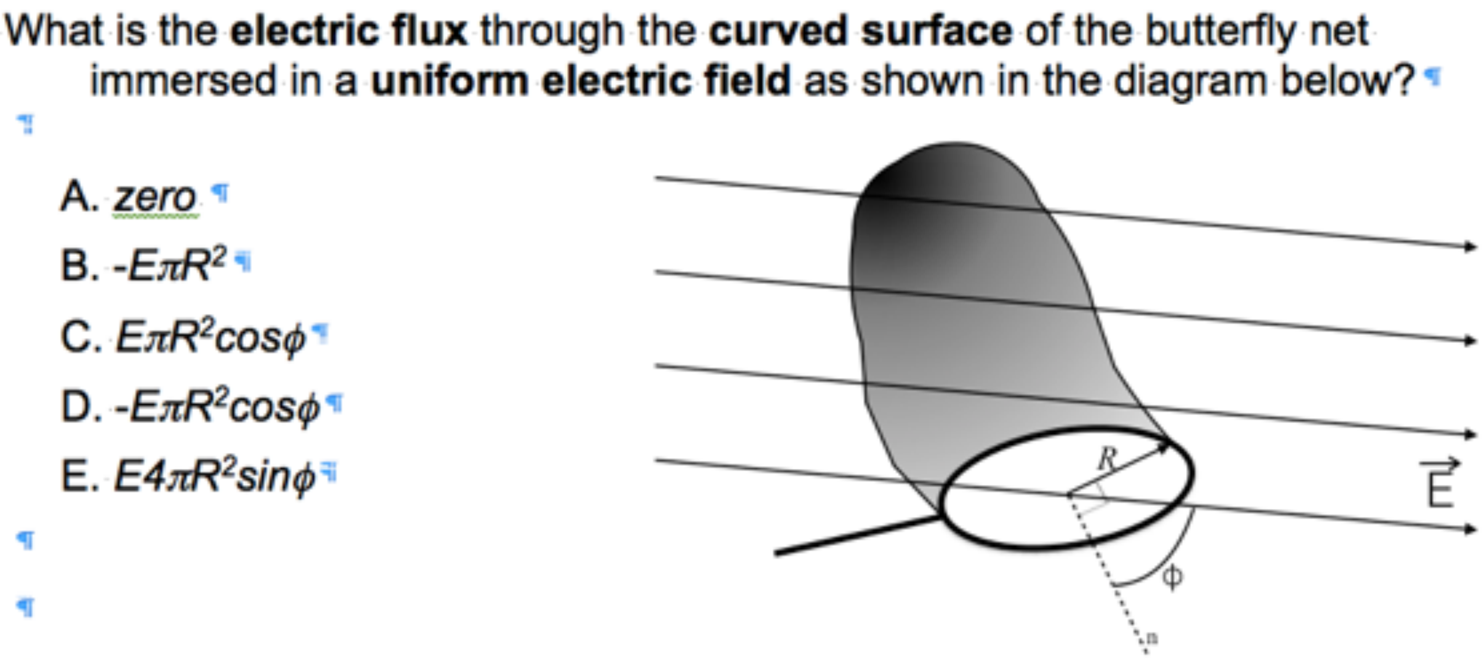
¶

¶

¶



Choices are different for TestID AA and BB

EC Q3 

What is the **electric flux** through the **curved surface** of the butterfly net immersed in a **uniform electric field** as shown in the diagram below?

A. *zero*

B. $-E\pi R^2$

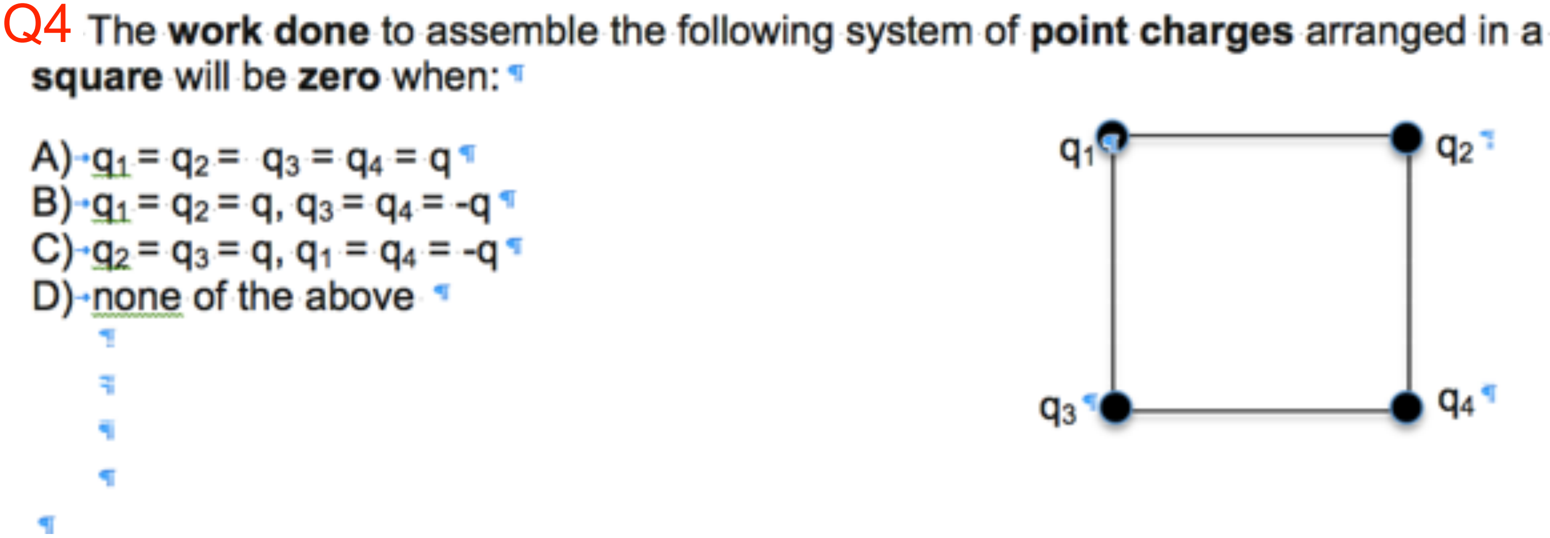
C. $E\pi R^2\cos\phi$

D. $-E\pi R^2\cos\phi$

E. $E4\pi R^2\sin\phi$

Choices are different for TestID AA and BB

EC Q4



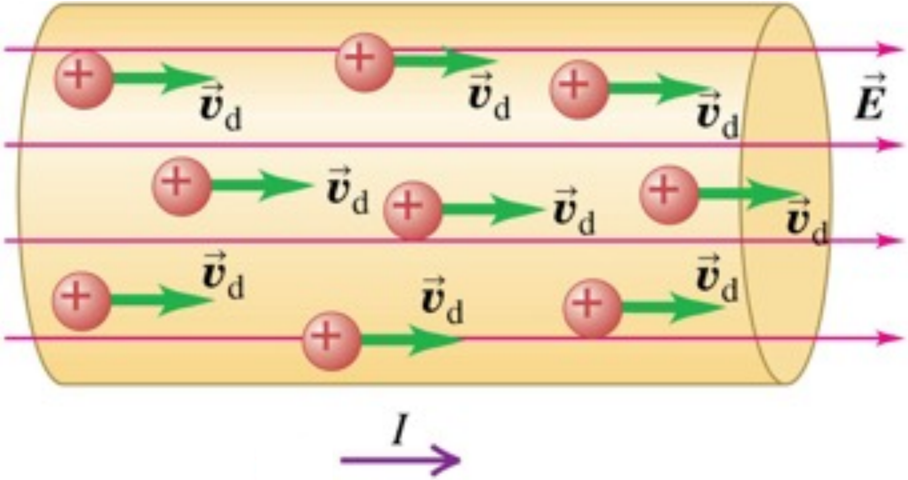
The **work done** to assemble the following system of **point charges** arranged in a **square** will be **zero** when:

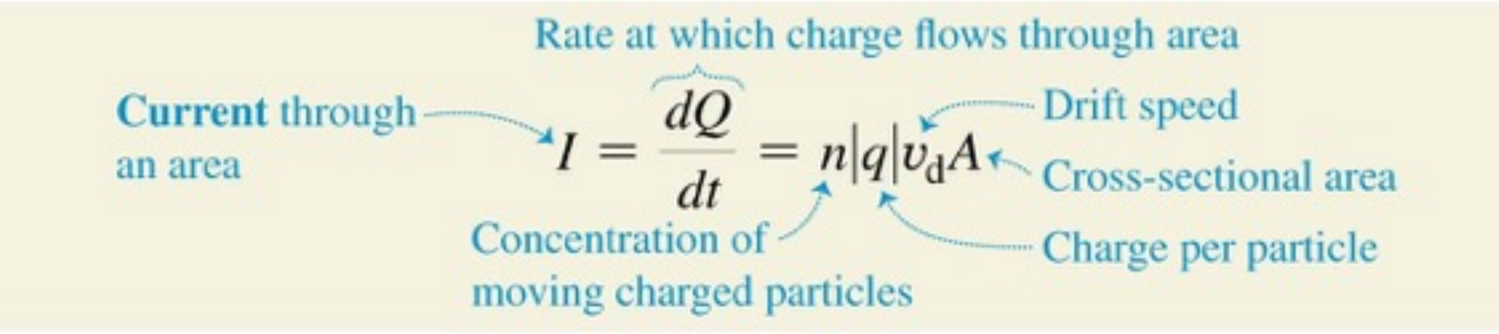
A) $q_1 = q_2 = q_3 = q_4 = q$
B) $q_1 = q_2 = q$, $q_3 = q_4 = -q$
C) $q_2 = q_3 = q$, $q_1 = q_4 = -q$
D) none of the above

Choices are different for TestID AA and BB

Current

- A **current** is any motion of charge from one region to another.

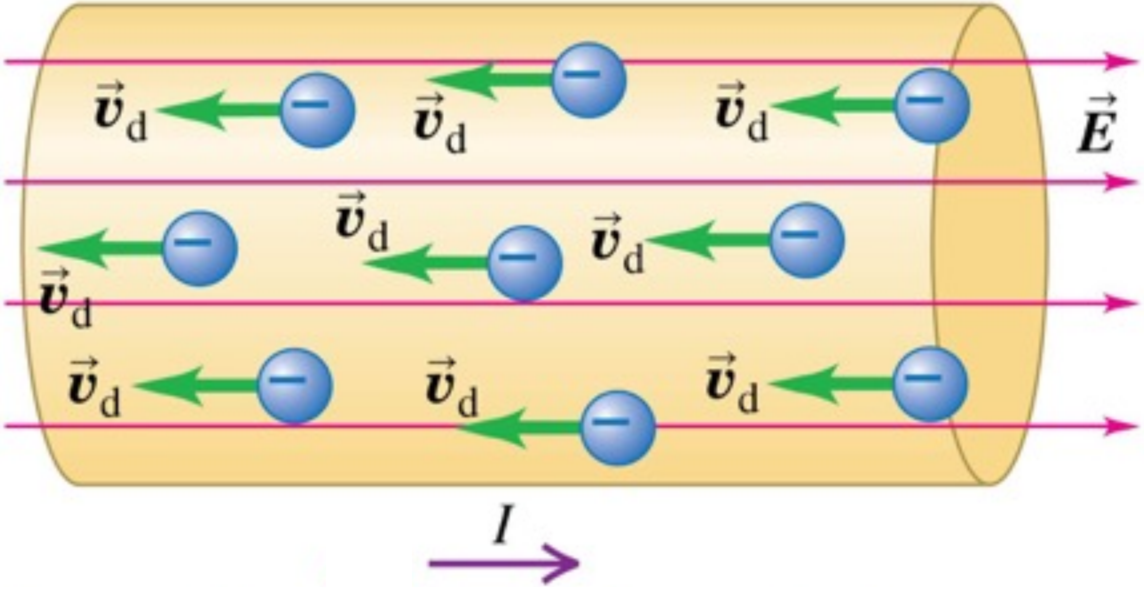




$$I = \frac{\overbrace{dQ}^{\text{Rate at which charge flows through area}}}{dt} = n|q|v_dA$$

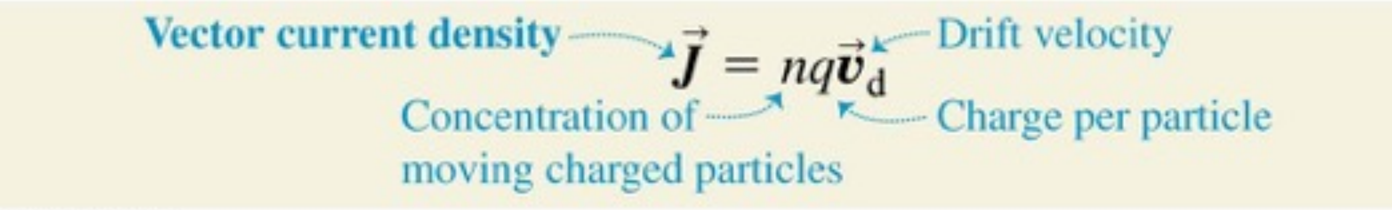
Direction of current flow

- A current can be produced by positive or negative charge flow.
- *Conventional current* is treated as a flow of positive charges.
- In a metallic conductor, the moving charges are electrons — but the *current* still points in the direction positive charges would flow.



Current density

- We can define a *vector* current density that includes the direction of the drift velocity:



$$\vec{J} = nq\vec{v}_d$$

- The vector current density is always in the same direction as the electric field, no matter what the signs of the charge carriers are.

Resistivity

- The **resistivity** of a material is the ratio of the electric field in the material to the current density it causes:

Resistivity of a material

$$\rho = \frac{E}{J}$$

Magnitude of electric field in material

Magnitude of current density caused by electric field

- The *conductivity* is the reciprocal of the resistivity.
- The next slide shows the resistivity of various types of materials.

Resistivities at room temperature (20°C)

	Substance	**ρ ($\Omega \cdot$ m)**
	Copper	1.72×10^{-8}
Conductors	Gold	2.44×10^{-8}
	Lead	22×10^{-8}
Semiconductor:	Pure carbon (graphite)	3.5×10^{-5}
	Glass	$10^{10} – 10^{14}$
Insulators	Teflon	$>10^{13}$
	Wood	$10^{8} – 10^{11}$

Q25.1

Two copper wires of different diameter are joined end to end, and a current flows in the wire combination. When electrons move from the larger-diameter wire into the smaller-diameter wire,

A. their drift speed increases.

B. their drift speed decreases.

C. their drift speed stays the same.

D. either A or B is possible, depending on circumstances.

E. any of A, B, or C is possible, depending on circumstances.

Resistivities at room temperature (20°C)

	Substance	$\rho\ (\Omega \cdot \mathrm{m})$
Conductors	Copper	1.72×10^{-8}
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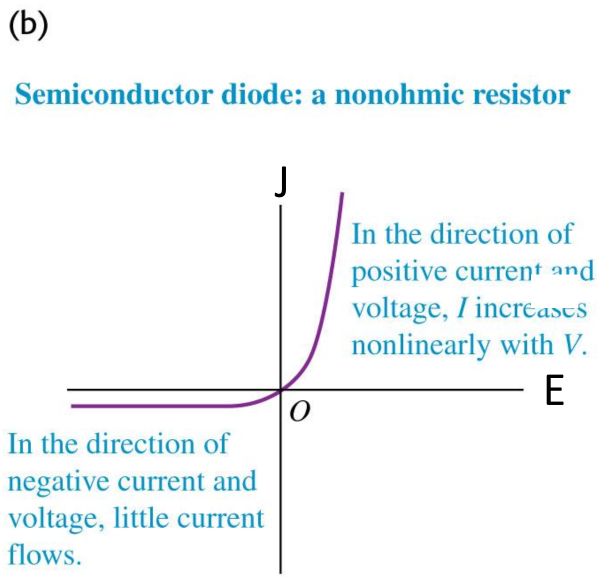
	Wood	$10^{8} - 10^{11}$

Caveats

- The resistivity of materials in general depends on temperature.
- Not all materials are ohmic.



Semiconductor diode: a nonohmic resistor

In the direction of positive current and voltage, I increases nonlinearly with V.

In the direction of negative current and voltage, little current flows.

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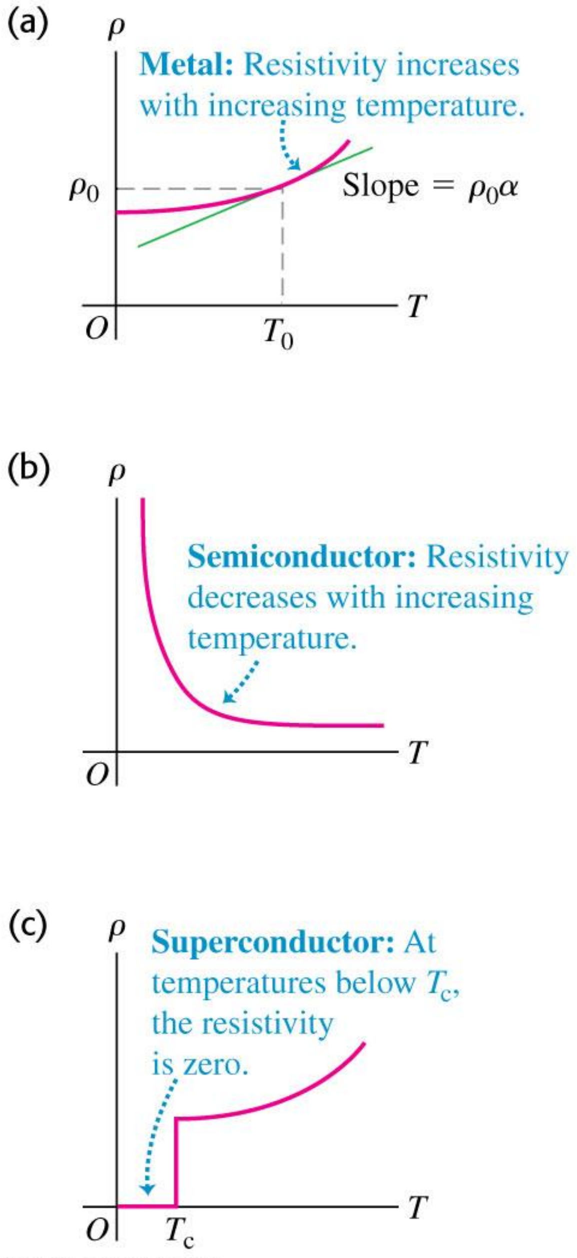

Metal: Resistivity increases with increasing temperature.

Semiconductor: Resistivity decreases with increasing temperature.

Superconductor: At temperatures below T_c, the resistivity is zero.

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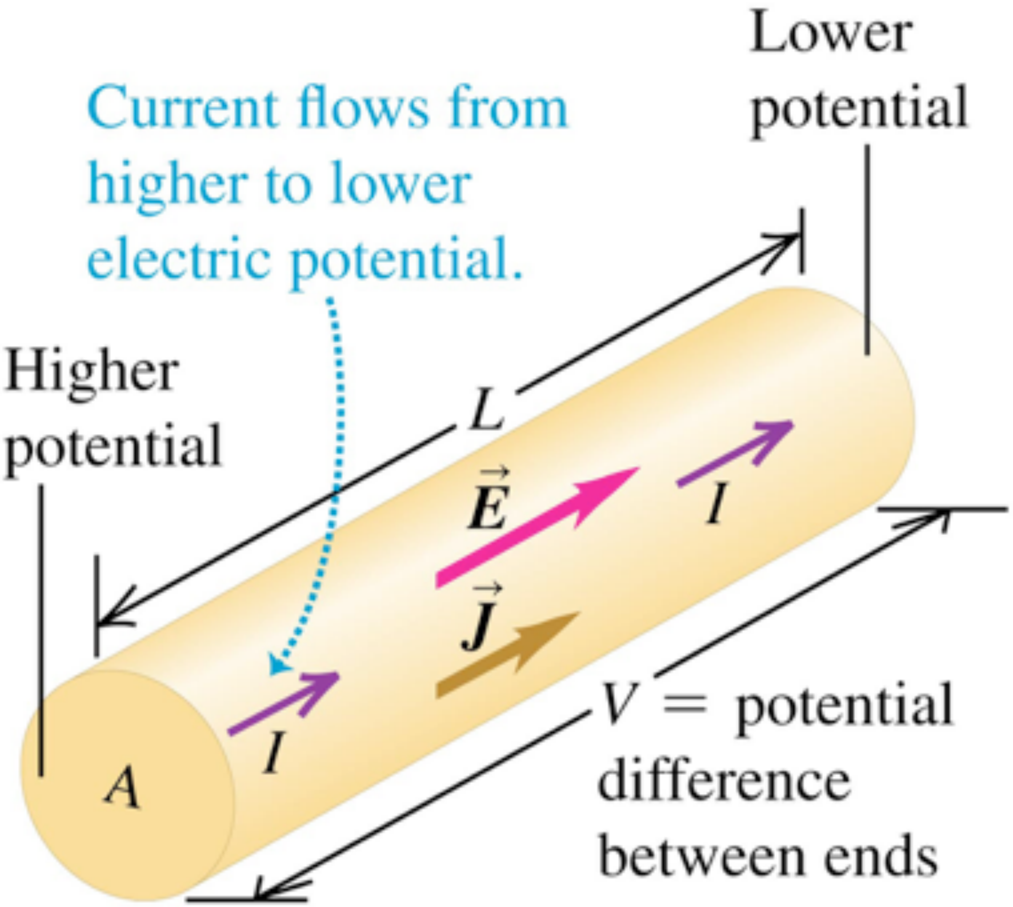
Resistance and Ohm's law

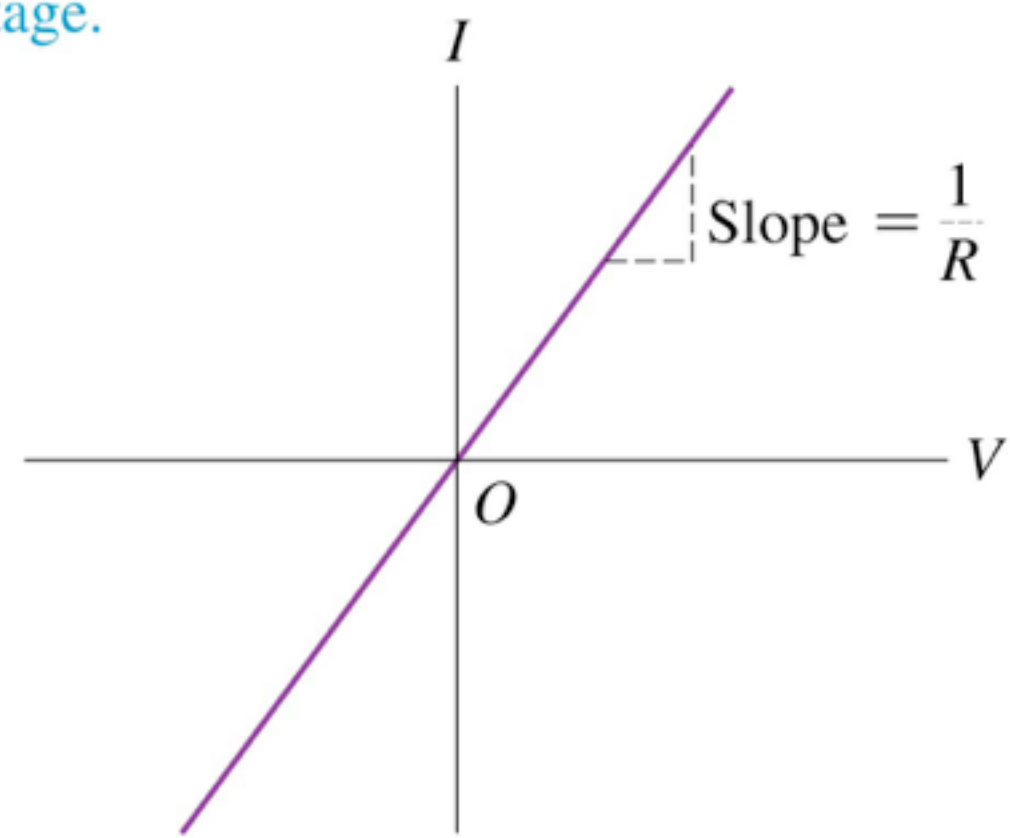
- The *resistance* of a conductor is $R = \rho L/A$.
- The potential across a conductor is given by Ohm's law: $V = IR$.



Ohmic resistors

- For a resistor that obeys Ohm's law, a graph of current as a function of potential difference (voltage) is a straight line.

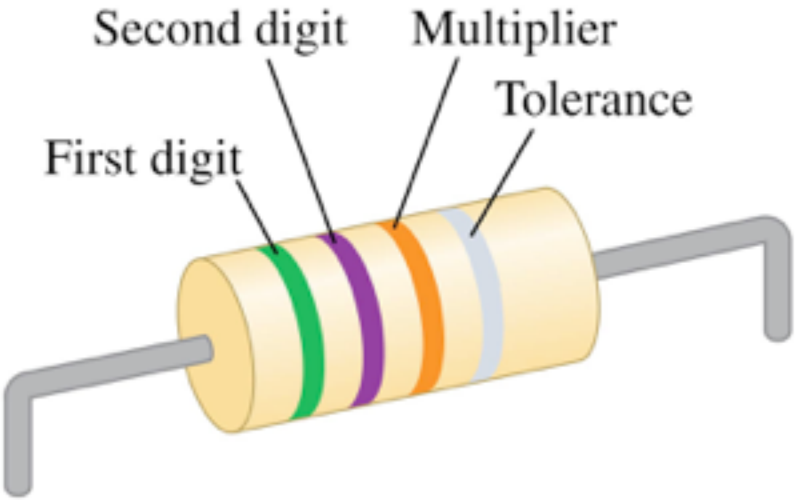
Ohmic resistor (e.g., typical metal wire): At a given temperature, current is proportional to voltage.



Resistors are color-coded for easy identification

- This resistor has a resistance of 5.7 kΩ with a tolerance of ±10%.

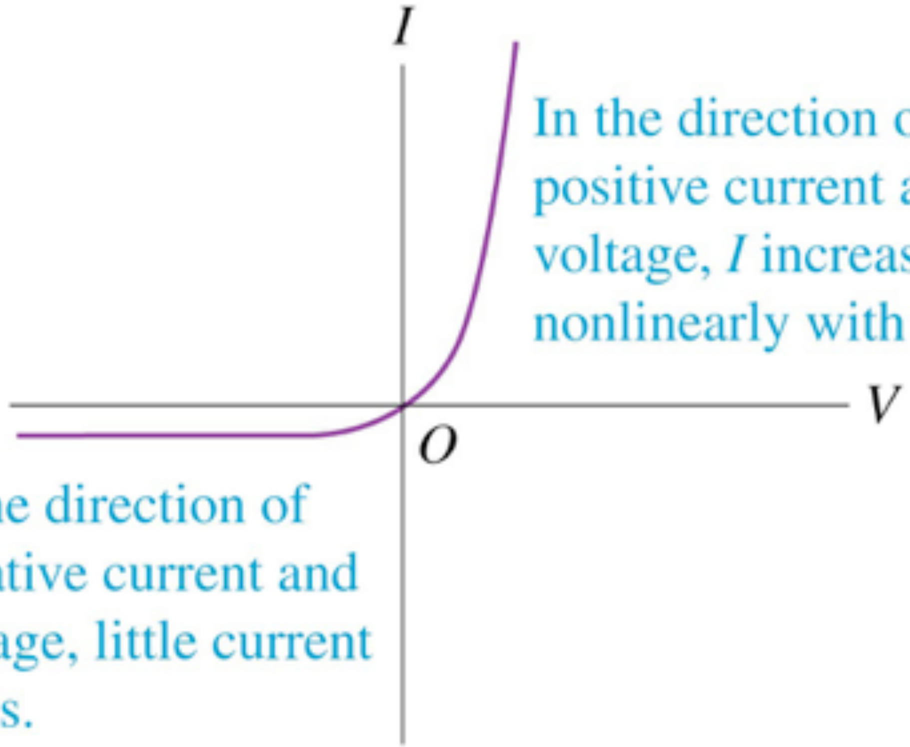
Color	Value as Digit	Value as Multiplier
Black	0	1
Brown	1	10
Red	2	10^2
Orange	3	10^3
Yellow	4	10^4
Green	5	10^5
Blue	6	10^6
Violet	7	10^7
Gray	8	10^8
White	9	10^9



Nonohmic resistors

- In devices that do not obey Ohm’s law, the relationship of voltage to current may not be a direct proportion, and it may be different for the two directions of current.

Semiconductor diode: a nonohmic resistor



In the direction of positive current and voltage, I increases nonlinearly with V.

In the direction of negative current and voltage, little current flows.

Q25.3

A source of emf is connected by wires to a resistor, and electrons flow in the circuit. The wire diameter is the same throughout the circuit. Compared to the *potential energy of an electron* before entering the *resistor*, the *potential energy of an electron* after leaving the *resistor* is

A. greater.

B. less.

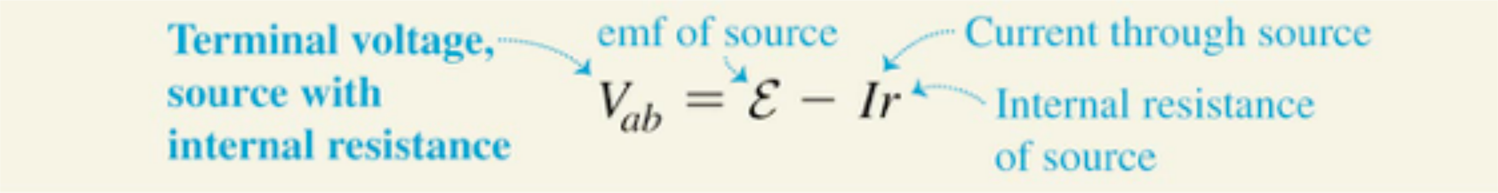
C. the same.

D. either A or B depending on circumstances.

E. any of A, B, or C depending on circumstances.

Internal resistance

- Real sources of emf actually contain some **internal resistance** r.
- The **terminal voltage** of the 12-V battery shown at the right is less than 12 V when it is connected to the light bulb.



$$V_{ab} = \mathcal{E} - Ir$$

Q25.2

A source of emf is connected by wires to a resistor, and electrons flow in the circuit. The wire diameter is the same throughout the circuit. Compared to the *drift speed* of the electrons before entering the *resistor*, the *drift speed* of the electrons after leaving the *resistor* is

A. faster.

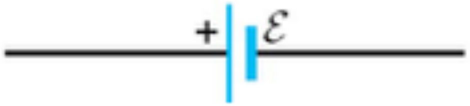
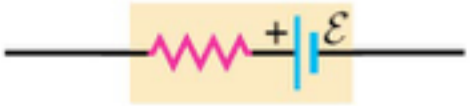
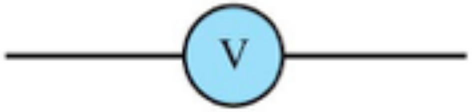
B. slower.

C. the same.

D. either A or B depending on circumstances.

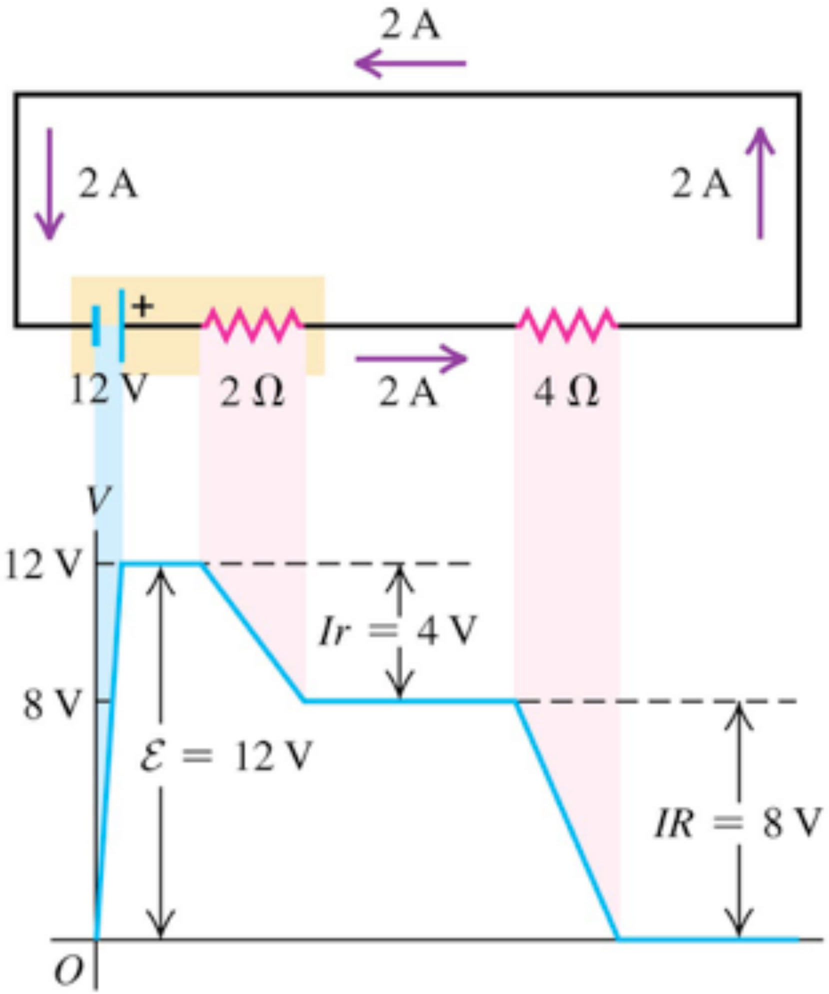
E. any of A, B, or C depending on circumstances.

Table 25.4 — Symbols for circuit diagrams

	Conductor with negligible resistance
	Resistor
	Source of emf (longer vertical line always represents the positive terminal, usually the terminal with higher potential)
 or 	Source of emf with internal resistance r (r can be placed on either side)
	Voltmeter (measures potential difference between its terminals)
	Ammeter (measures current through it)

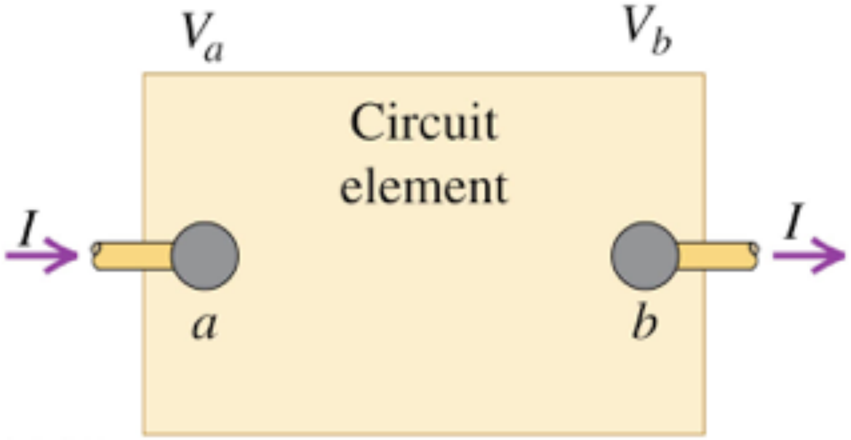
Potential changes

- The figure shows how the potential varies as we go around a complete circuit.
- The potential rises when the current goes through a battery, and drops when it goes through a resistor.
- Going all the way around the loop brings the potential back to where it started.



Energy and power in electric circuits

- The box represents a circuit element with potential difference $V_{ab} = V_a - V_b$ between its terminals and current I passing through it in the direction from *a* toward *b*.



- If the potential at *a* is lower than at *b*, then there is a net transfer of energy out of the circuit element.
- The time rate of energy transfer is power, denoted by *P*, so we write:

Power delivered to or extracted from a circuit element

$$P = V_{ab} I$$

Voltage across circuit element

Current in circuit element

COMING Soon! Ch. 26 Pre-class — resistor networks

7) The figure shows three identical light bulbs connected to a battery having a constant voltage across its terminals. What happens to the brightness of light bulb 3 when the switch *S* is closed?