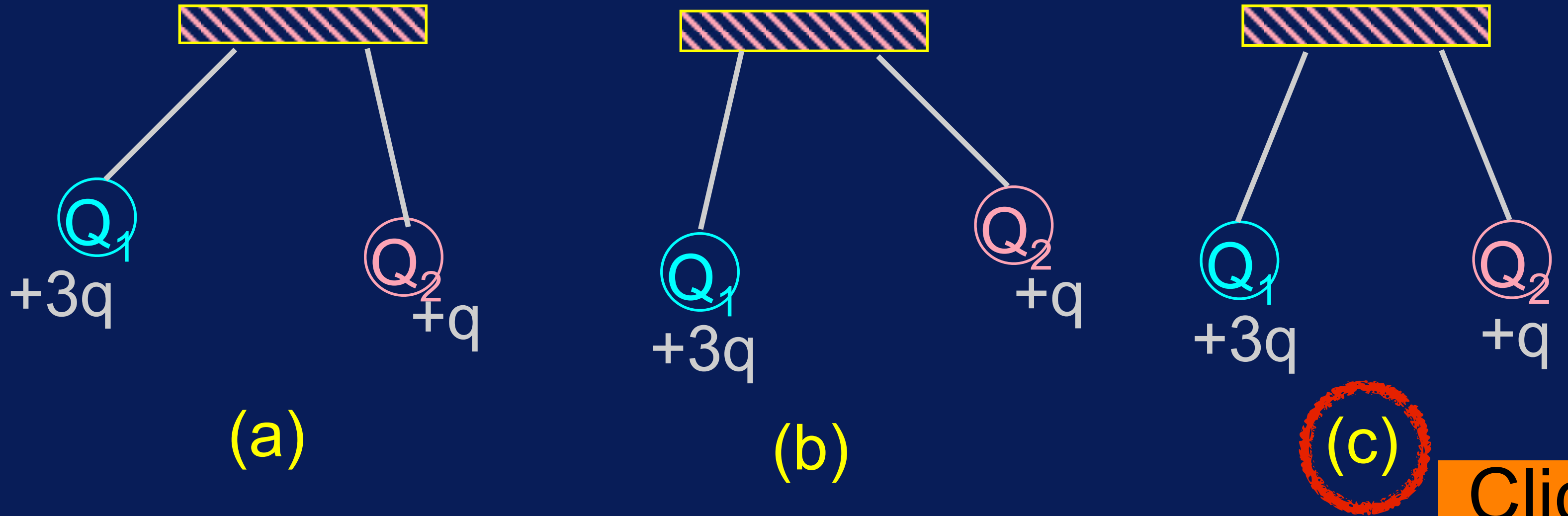
Lecture 2

Two equal mass balls are suspended from the ceiling with equal length nonconducting threads as shown. Ball 1 has charge $Q_1 = +3q$ and Ball 2 has charge $Q_2 = +q$.

– Which of the following pictures best represents the equilibrium position?



Clicker 2-1

Clicker 2-2

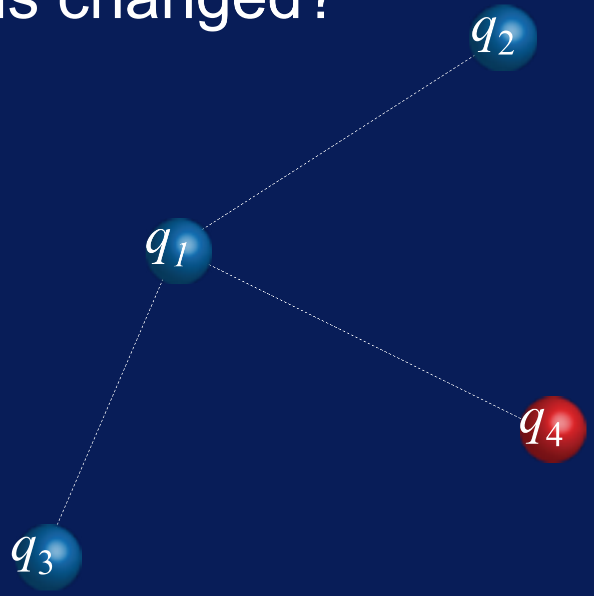
What happens to the Force on q_1 if its sign is changed?

A) $|F_1|$ increases

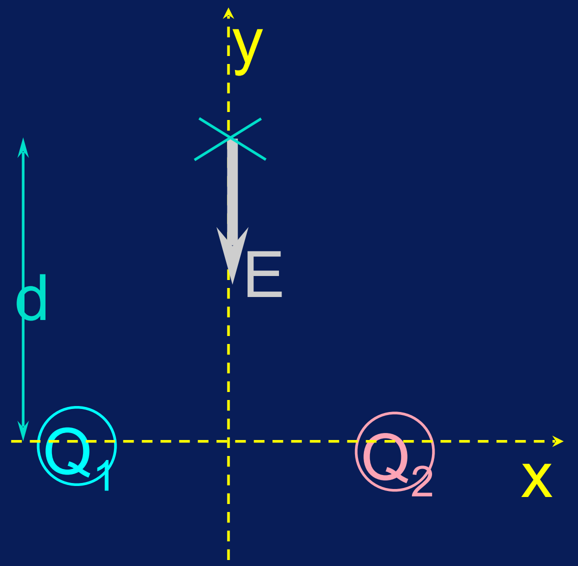
B) $|F_1|$ remains the same

C) $|F_1|$ decreases

D) Need more information to determine



- Two charges, Q_1 and Q_2 , fixed along the x-axis as shown, produce an electric field E at a point (x,y) = (0,d) which is directed along the negative y-axis.
  - Which is true?



(a) Both charges Q_1 and Q_2 must be positive.

(b) Both charges Q_1 and Q_2 must be negative.

(c) The charges Q_1 and Q_2 must have opposite signs.

Clicker 2-3

- Q_1 has charge +Q
- Q_2 has charge +2Q
- They are separated by d.
- Charge q is a distance a away from Q_1

Is there a place – the value for a -- between Q_1 and Q_2 where the force on ANY charge (positive or negative) is zero?

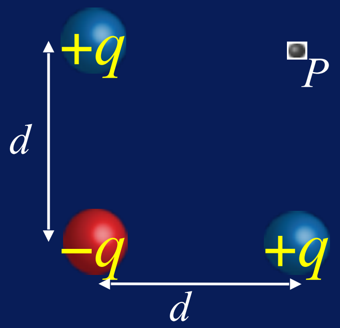
(a) NO

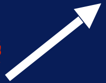
(b) Yes, but I can’t find it with all this time pressure.

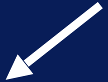
(c) Yes and my answer is ________ from Q_1. I will volunteer to specify if you ask me

Clicker 2-4

What is the direction of the electric field at point P, the unoccupied corner of the square?



A) 

B) 

C) $E = 0$

D) Need to know d

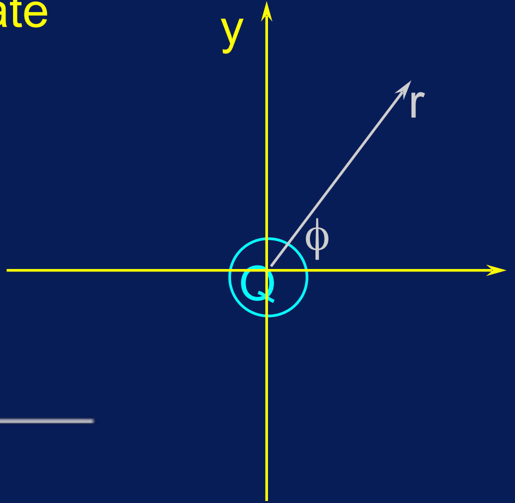
E) Need to know d & q

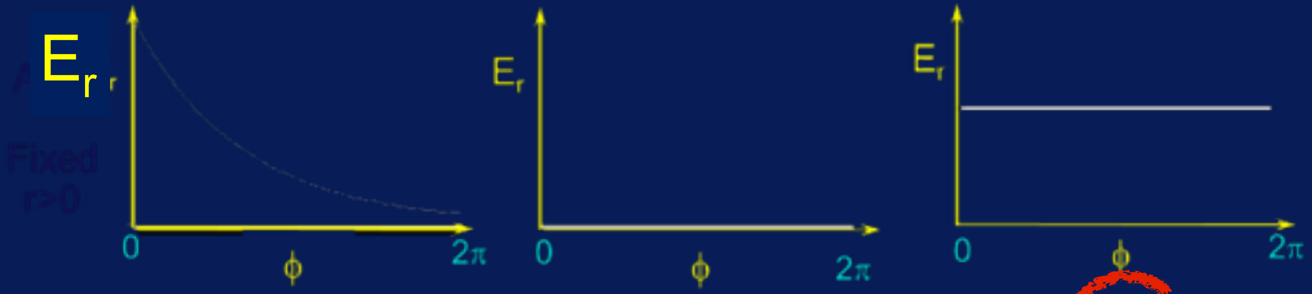
Clicker 2-5

Lecture 3

Consider a point charge fixed at the origin of a co-ordinate system as shown.

Which of the following graphs best represents the functional dependence of the Electric Field?



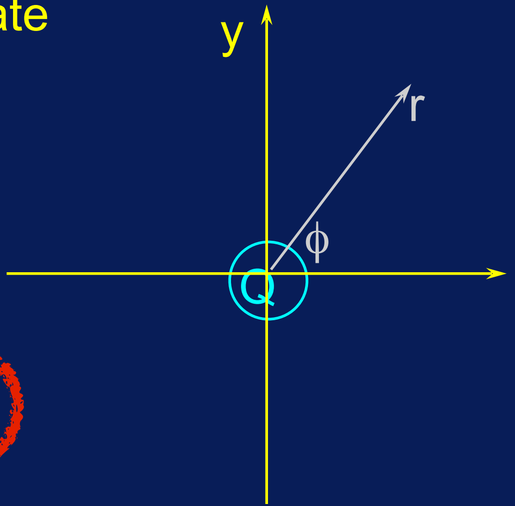


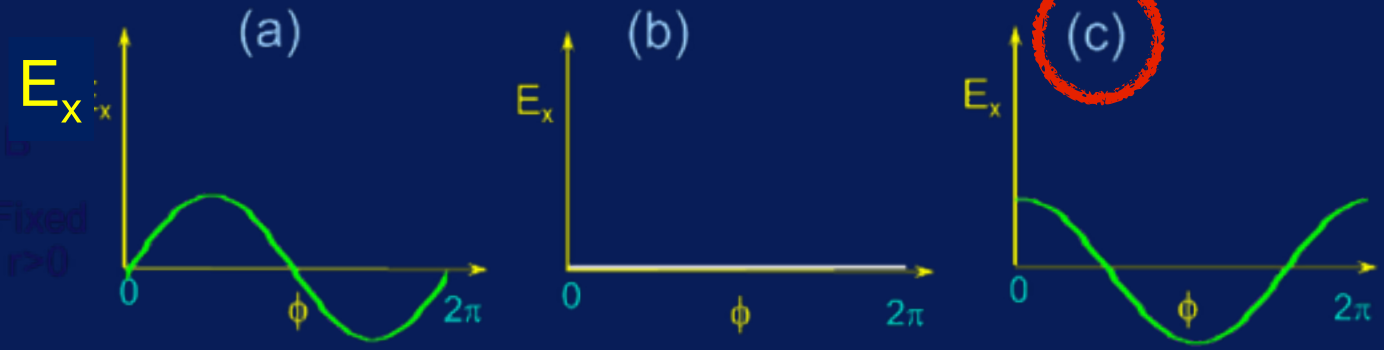
(a) (b) (c)

Clicker 3-1

Consider a point charge fixed at the origin of a co-ordinate system as shown.

Which of the following graphs best represents the functional dependence of the Electric Field?



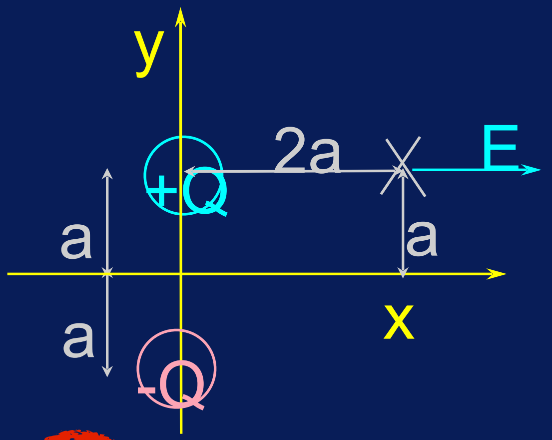


Clicker 3-2

Clicker

Consider a dipole aligned with the y-axis as shown.

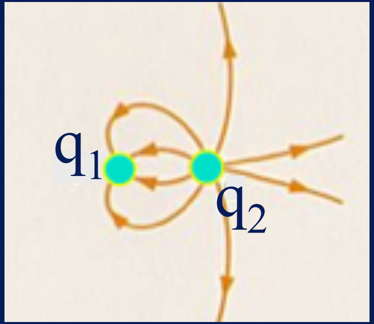
Which of the following statements about $E_x(2a,a)$ is true?



(a) $E_x(2a,a) < 0$ (b) $E_x(2a,a) = 0$ (c) $E_x(2a,a) > 0$

Examine the electric field lines produced by the 2 charges in this figure.

Which statement is true?



(a) q_1 and q_2 have the same sign

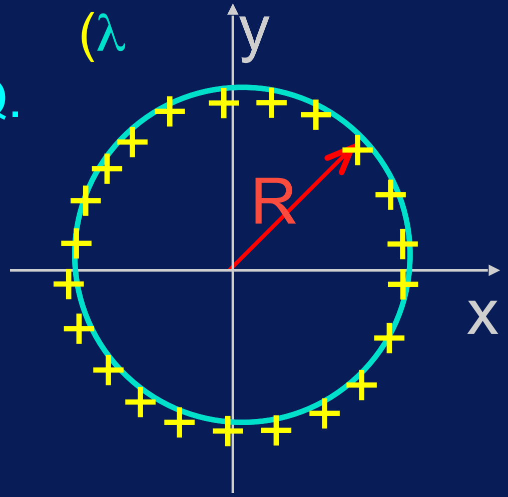
(b) q_1 and q_2 have the opposite signs and $|q_1| > |q_2|$

(c) q_1 and q_2 have the opposite signs and $|q_1| < |q_2|$

Clicker 3-4

Lecture 4

Consider a circular ring with a uniform charge distribution (λ charge per unit length). The total charge of this ring is +Q.

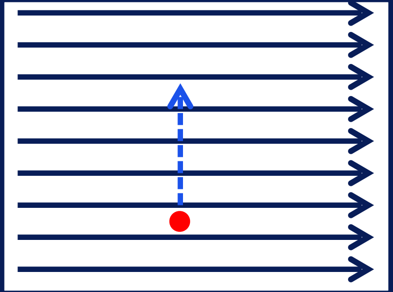


The electric field at the origin is

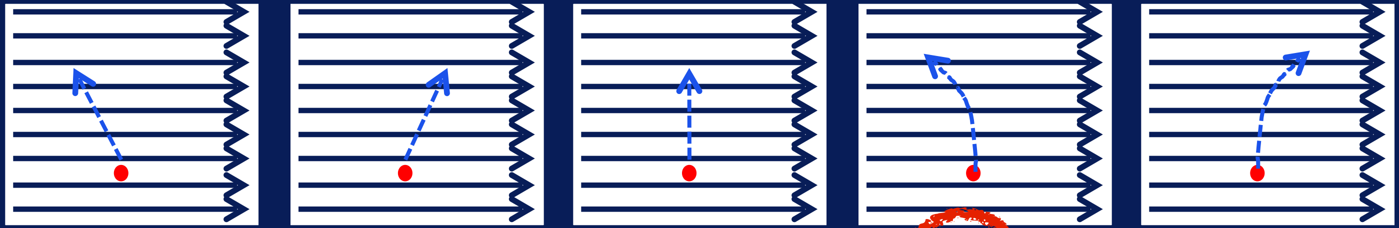
(a) zero (b) $\frac{1}{4\pi\varepsilon_0}\frac{2\pi\lambda}{R}$ (c) $\frac{1}{4\pi\varepsilon_0}\frac{\pi R\lambda}{R^2}$

Clicker 4-1

An electron is fired upward at speed v_0 toward the top of the page as shown. A uniform electric field points to the right.



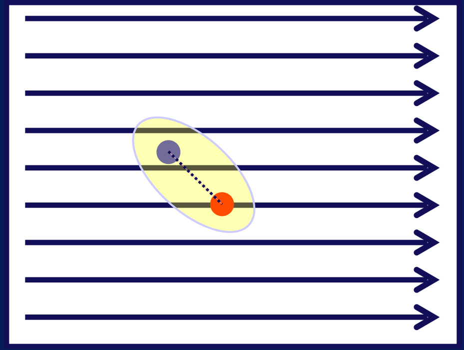
Which trajectory best represents its motion:



(A) (B) (C) (D) (E)

Clicker 4-2

An electric dipole consists of two equal and opposite charges, fixed a distance 2a apart. It is placed in a uniform electric field as shown. It will (red is pos)



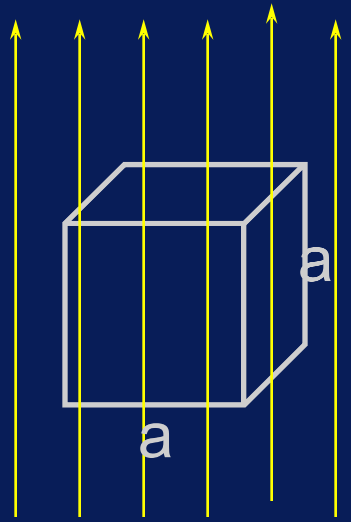
Not translate in any direction

A. Translate horizontally
B. Translate vertically
C. Start to rotate clockwise
D. Start to rotate counter-clockwise

Clicker 4-3

Imagine a cube of side a positioned in a region of constant electric field as shown.

– Which of the following statements about the electric flux Φ_E through the surface of this cube is true?



(a) $\Phi_E = 0$ (b) $\Phi_E \propto 2a^2$ (c) $\Phi_E \propto 6a^2$

Clicker 4-4

Consider 2 spheres (of radius R and 2R) drawn around an electric dipole

Which of the following statements about the net electric flux through the 2 surfaces (Φ_{2R} and Φ_R) is true?

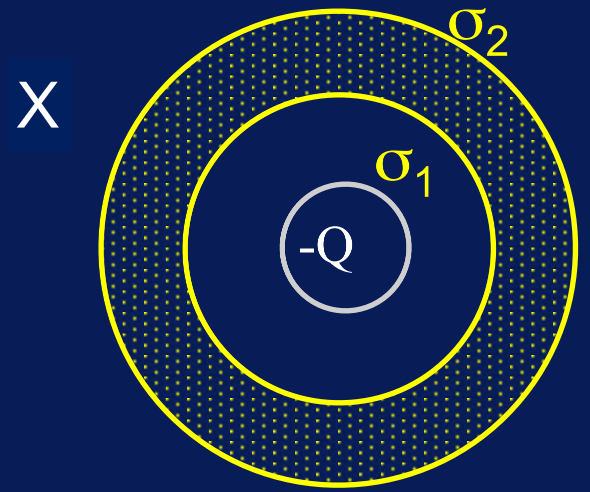
(a) $\Phi_R < \Phi_{2R}$ (b) $\Phi_R = \Phi_{2R}$ (c) $\Phi_R > \Phi_{2R}$

Clicker 4-5

Lecture 5

A $Q = -3\ \mu C$ charge is surrounded by an uncharged conducting spherical shell (in yellow)

Compare the electric field at point X to the one you would find if the conducting shell was removed.



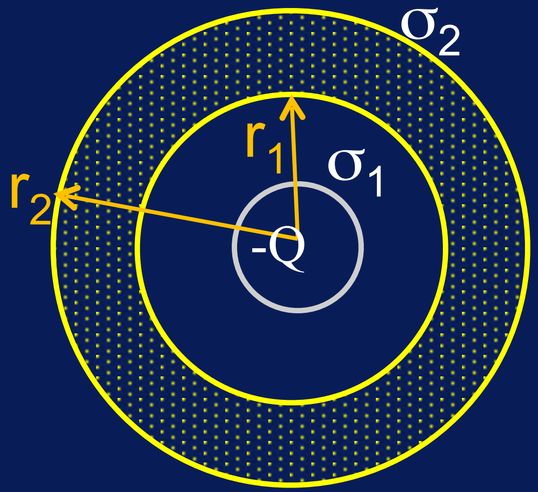
(a) $E_{shell} < E_{NoShell}$ (b) $E_{shell} = E_{NoShell}$ (c) $E_{shell} > E_{NoShell}$

Clicker 5-1

Clicker 5-2

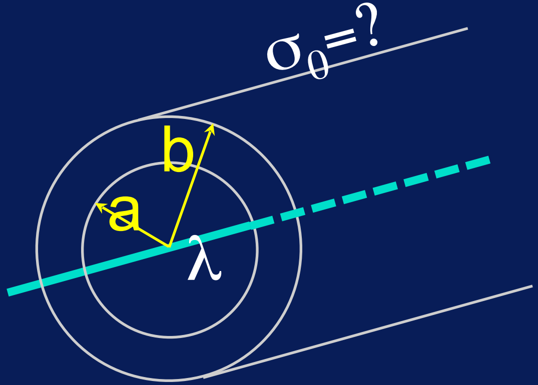
A $Q = -3\ \mu C$ charge is surrounded by an uncharged conducting spherical shell (in yellow)

What is the value of the surface charge density σ_1 on the inner surface of the conducting shell?



(a) $\sigma_1 = -Q$ (b) $\sigma_1 = +Q$ (c) $\sigma_1 = 0$ (d) $\sigma_1 = \frac{-Q}{4\pi\varepsilon_0 r_1^2}$ (e) $\sigma_1 = \frac{+Q}{4\pi\varepsilon_0 r_1^2}$

A line charge λ C/m is placed along the axis of an uncharged conducting cylinder of inner radius r_i = a, and outer radius r_o = b as shown.



What is the value of the charge density σ_o (C/m^2) on the outer surface of the cylinder?

(a) $\sigma_o = -\frac{\lambda}{2\pi b}$ (b) $\sigma_o = 0$ (c) $\sigma_o = +\frac{\lambda}{2\pi b}$

Clicker 5-3

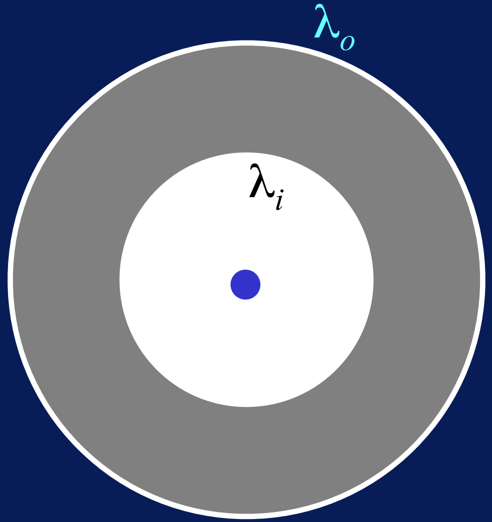
Lecture 6

Clicker 6-1

A long thin wire has a uniform positive charge density of 2.5 C/m. Concentric with the wire is a long thick conducting cylinder, with inner radius 3 cm, and outer radius 5 cm. The conducting cylinder has a net linear charge density of –4 C/m.

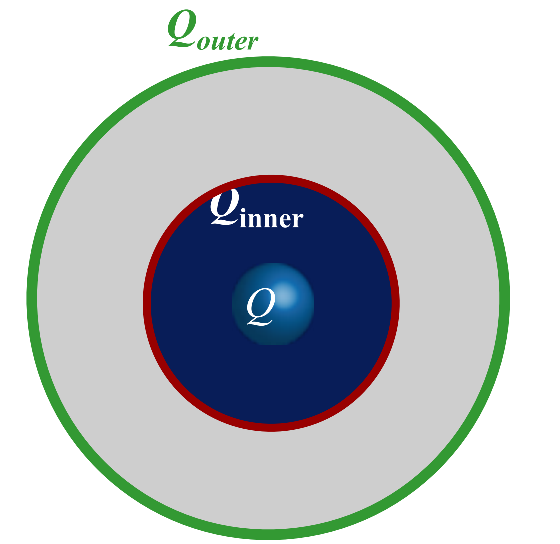
What is the linear charge density of the induced charge on the inner surface of the conducting cylinder (λ_i) and on the outer surface (λ_o)?

	A	B	C	D	E
λ_i:	+2.5 C/m	–4 C/m	–2.5 C/m	–2.5 C/m	0
λ_o:	–6.5 C/m	0	+2.5 C/m	–1.5 C/m	–4 C/m



Clicker 6-2

A particle with charge $+Q$ is placed in the center of an uncharged conducting hollow sphere. How much charge will be induced on the inner and outer surfaces of the sphere?



A) inner = $-Q$, outer = $+Q$

B) inner = $-Q/2$, outer = $+Q/2$

C) inner = 0, outer = 0

D) inner = $+Q/2$, outer = $-Q/2$

E) inner = $+Q$, outer = $-Q$

You hold a positively charged ball and walk to the right in a region that contains an electric field directed to the left.

Clicker 6-3

W_H is the work done by the hand on the ball

W_E is the work done by the electric field on the ball

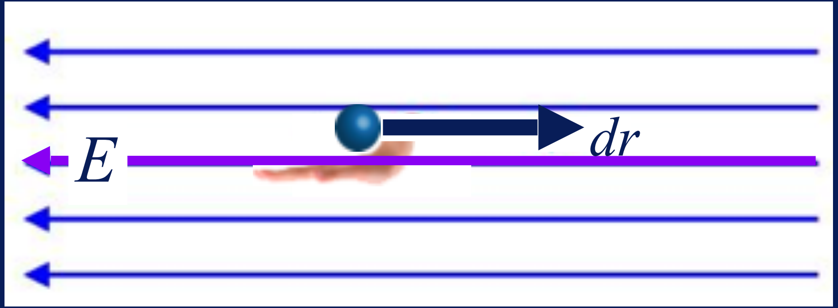
Which of the following statements is true:

A) $W_H > 0$ and $W_E > 0$

B) $W_H > 0$ and $W_E < 0$

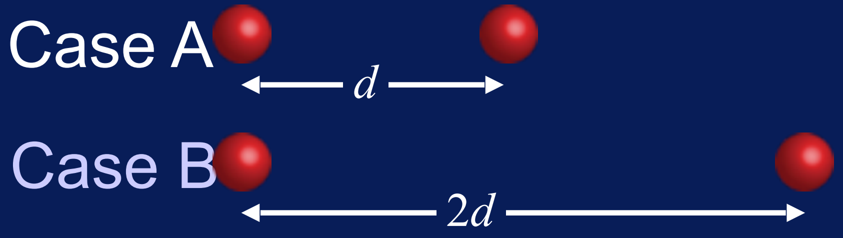
C) $W_H < 0$ and $W_E < 0$

D) $W_H < 0$ and $W_E > 0$



In Case A two negative charges which are equal in magnitude are separated by a distance d. In Case B the same charges are separated by a distance $2d$. Which configuration has the highest potential energy?

- A) Case A
- B) Case B



Clicker 6-4

What is the total energy required to bring in three identical charges, from infinitely far away to the points on an equilateral triangle shown.

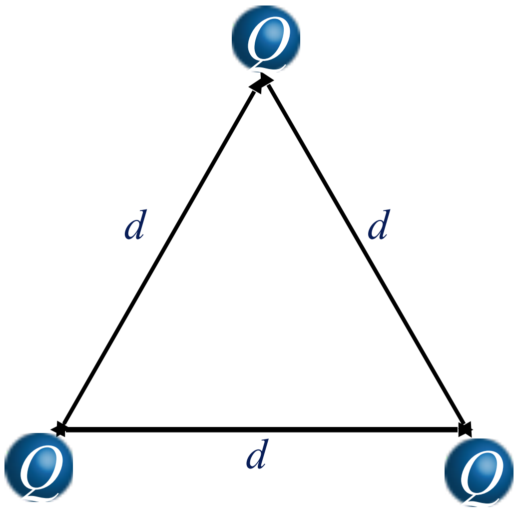
A) 0

B) $\Delta U = \frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

C) $\Delta U = 2\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

D) $\Delta U = 3\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

E) $\Delta U = 6\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$



Clicker 6-5

Lecture 7

Suppose one of the charges is negative. Now what is the total energy required to bring the three charges in infinitely far away?

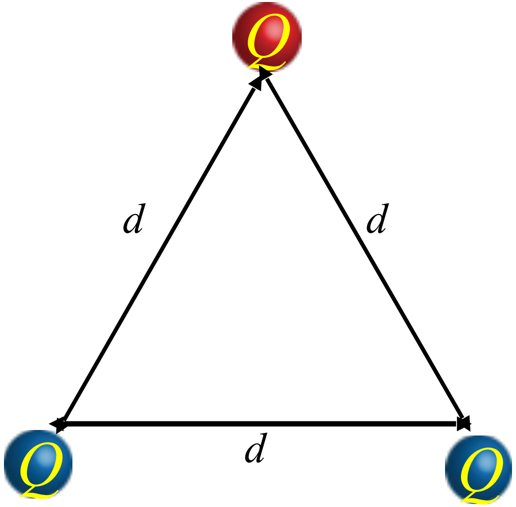
A) 0

B) $\Delta U = +1\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

C) $\Delta U = -1\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

D) $\Delta U = +2\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$

E) $\Delta U = -2\frac{Q^2}{4\pi\varepsilon_0}\frac{1}{d}$



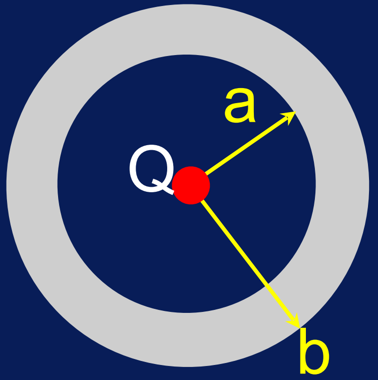
Clicker 7-1

Lecture 8

A point charge Q is fixed at the center of an uncharged conducting spherical shell of inner radius a and outer radius b.

1A

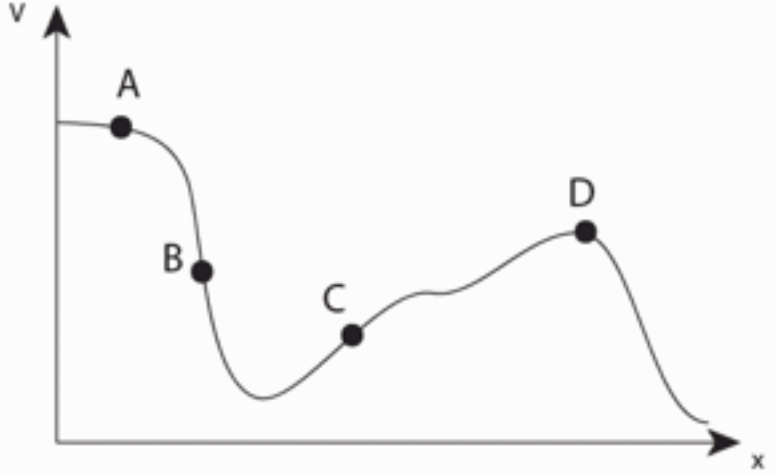
– What is the value of the potential V_a at the inner surface of the spherical shell?



(a) $V_a = 0$ (b) $V_a = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a}$ (c) $V_a = \frac{1}{4\pi\varepsilon_0}\frac{Q}{b}$

Clicker 8-1

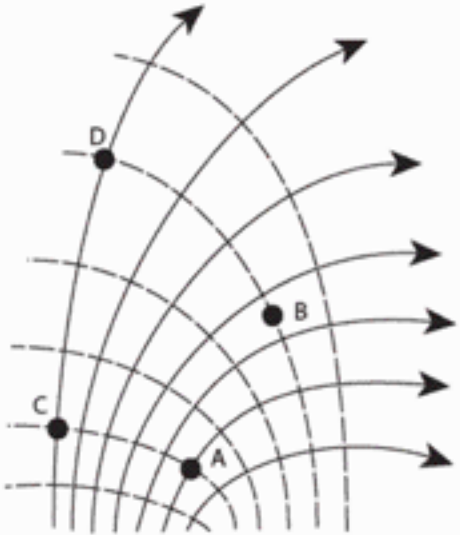
Clicker 8-2



At which point is the direction of the E field along the negative x axis ?

A **B** **C** **D** **E = none of these**

Clicker 8-3



What is the sign of W_{AC} = work done by E field to move negative charge from A to C ?

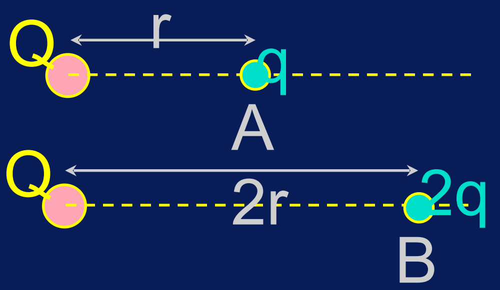
A) $W_{AC} < 0$ B) $W_{AC} = 0$ C) $W_{AC} > 0$

Lecture 9

Clicker 9-1

Two test charges are brought separately to the vicinity of positive charge Q.

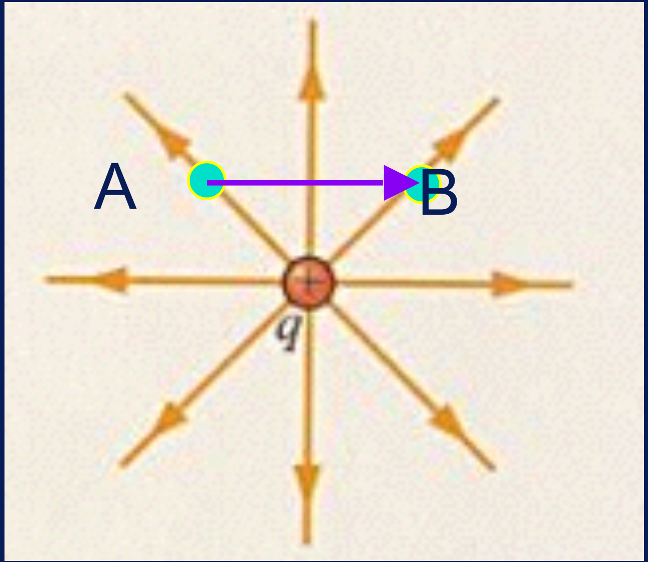
- **Charge +q is brought to A, a distance r from Q.**
- **Charge + 2q is brought to B, a distance 2r from Q.**
- **Compare the potential at A (V_A) to that at B:**



(a) $V_A < V_B$ (b) $V_A = V_B$ (c) $V_A > V_B$

Clicker 9-2

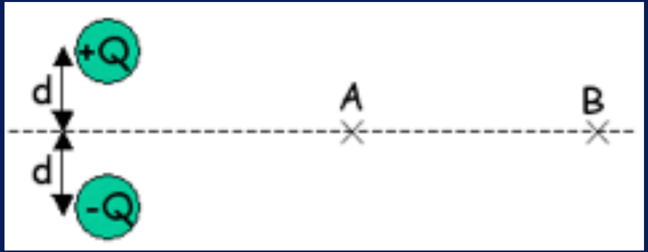
A positive charge Q is moved from A to B along the path shown. What is the sign of the work done to move the charge from A to B?



(a) $W_{AB} < 0$ (b) $W_{AB} = 0$ (c) $W_{AB} > 0$

Clicker 9-3

An electric dipole with charge magnitude Q and separation 2d is oriented as shown below. Compare V_A, the electric potential at point A, with V_B, the electric potential at point B.

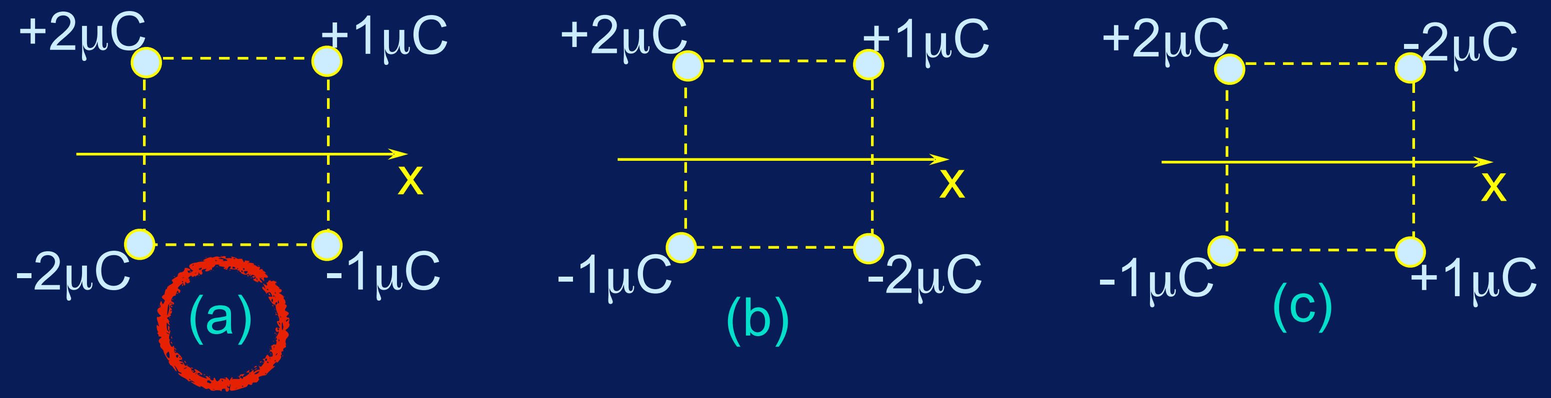


(a) $V_A < V_B$

(b) $V_A = V_B$

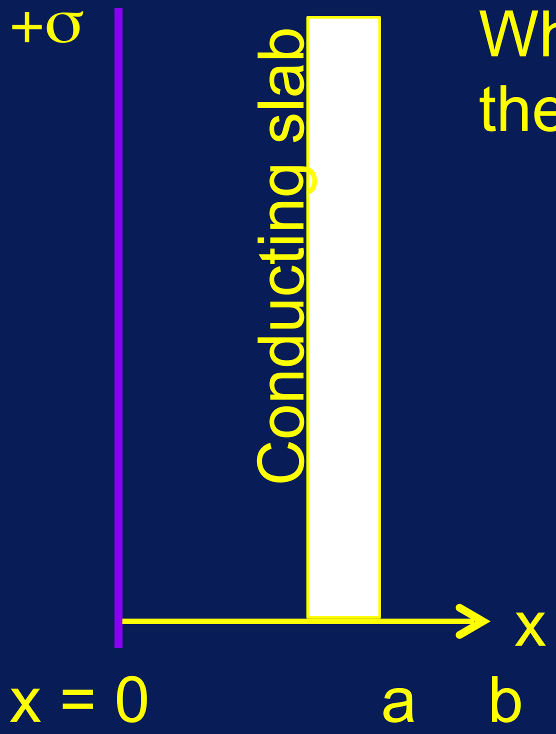
(c) $V_A > V_B$

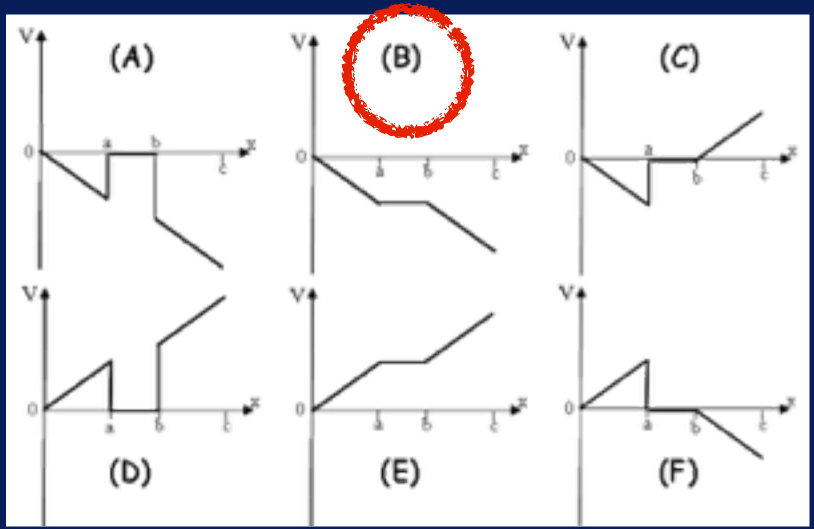
Which of the following charge distributions produces V(x) = 0 for all points on the x axis? (we are defining V(x) ≡ 0 at x = ∞)



Clicker 9-4

Which curve best represents the Potential in the positive x direction?



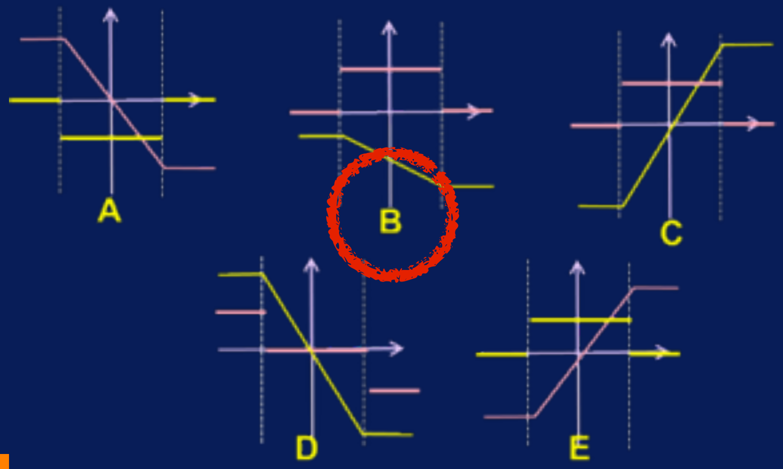


Clicker 9-5

Lecture 10

$+\sigma$

Two "infinite" oppositely charged parallel plates are located at –d and +d on the x axis. Which graphs best represent the Electric Field and the Potential Difference vs x ?

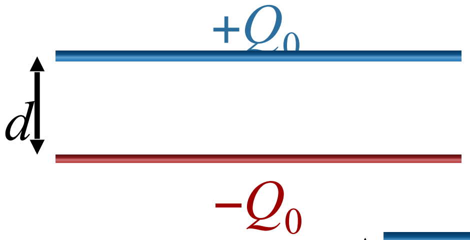


$-\sigma$

Clicker 10-1

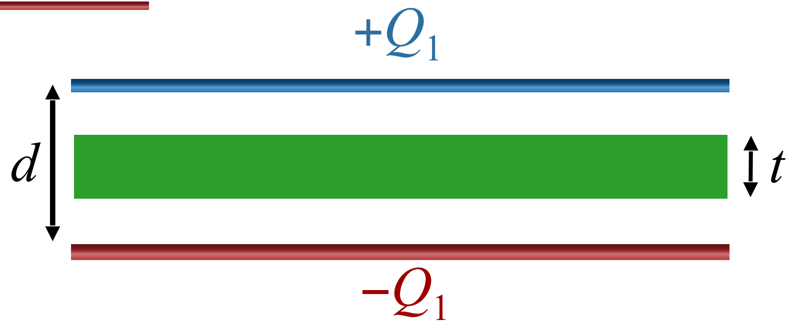
Clicker 10-2

Initial charge on capacitor $= Q_0$



Insert uncharged conductor

Charge on capacitor now $= Q_1$



How is Q_1 related to Q_0 ?

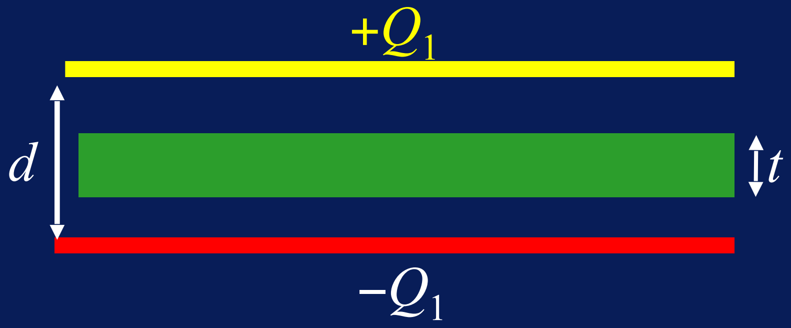
A) $Q_1 < Q_0$

B) $Q_1 = Q_0$

C) $Q_1 > Q_0$

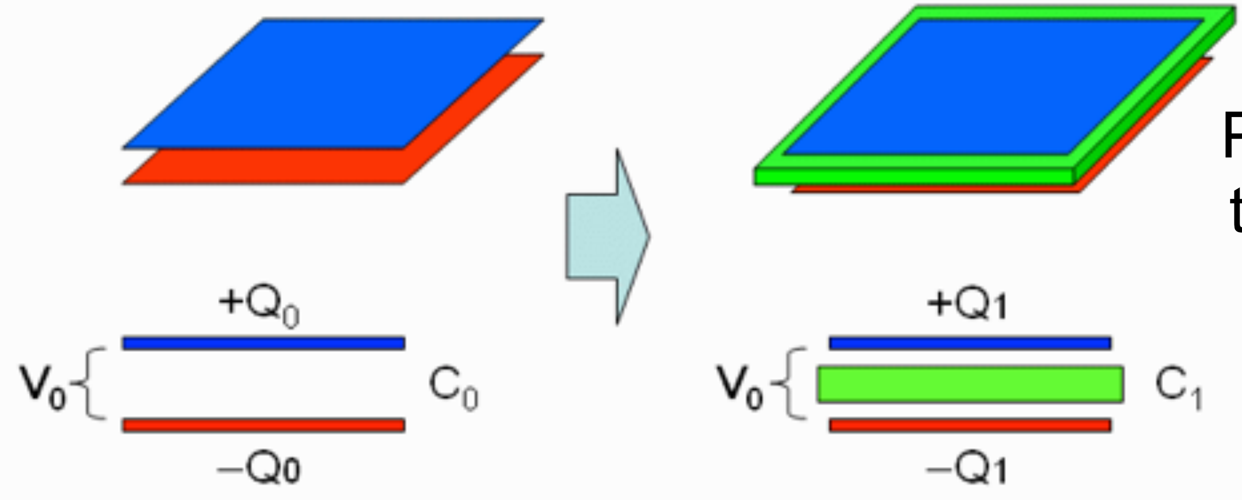
What is the total charge induced on the bottom surface of the conductor?

(Initial charge on capacitor $= Q_0$)



A) $+Q_0$
B) $-Q_0$
C) 0
D) Positive but the magnitude is unknown
E) Negative but the magnitude is unknown

Clicker 10-3

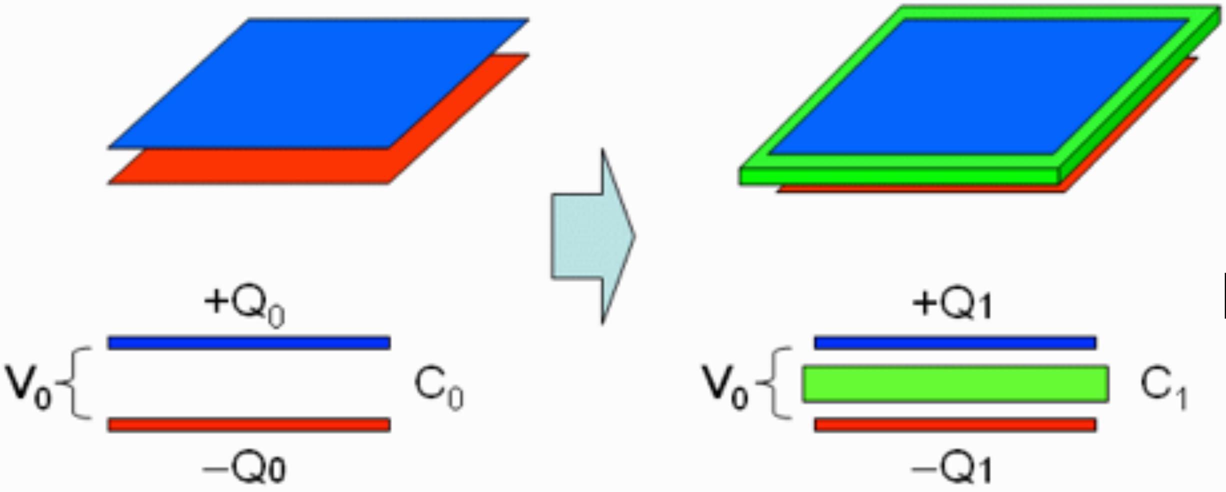


Potential difference is the **SAME** as before. (we adjusted it)

How is charge Q_1 related to the original Q_0 ?

A) $Q_1 < Q_o$ B) $Q_1 = Q_o$ C) $Q_1 > Q_o$

Clicker 10-3



We adjusted Q_1 to make the Potential Difference the Same

How did the Capacitance of the object change?

A) $C_1 > C_o$ B) $C_1 = C_o$ C) $C_1 < C_o$

Clicker 10-4

Lecture 11

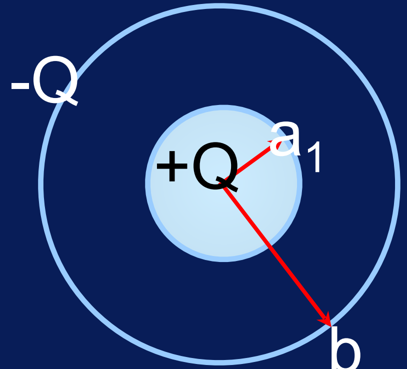
In each case below, a charge of +Q is placed on a solid spherical conductor and a charge of -Q is placed on a concentric conducting spherical shell.

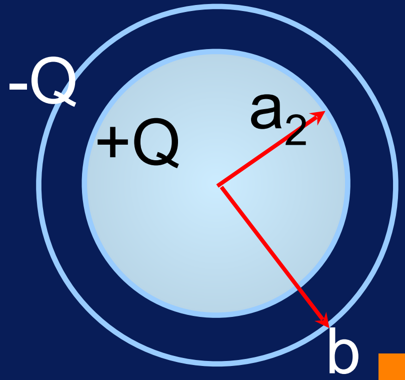
- Let V_1 be the potential difference between the spheres with (a_1, b).
- Let V_2 be the potential difference between the spheres with (a_2, b).
- What is the relationship between V_1 and V_2?

(a) $V_1 < V_2$

(b) $V_1 = V_2$

(c) $V_1 > V_2$





Clicker 11-1

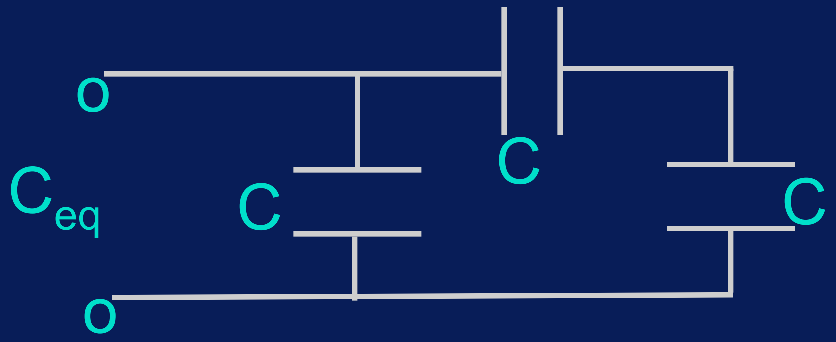
Suppose you have two identical capacitors, each having capacitance C. C_{max} is the biggest possible equivalent capacitance that can be made by combining these two, and C_{min} is the smallest.

How does C_{max} compare to C_{min}?

A. $C_{max} = 4C_{min}$
B. $C_{max} = 3C_{min}$
C. $C_{max} = 2C_{min}$
D. $C_{max} = (3/2)C_{min}$
E. $C_{max} = C_{min}$

Clicker 11-2

What is the equivalent capacitance, C_{eq}, of the combination shown?



(a) $C_{eq} = (3/2)C$ (b) $C_{eq} = (2/3)C$ (c) $C_{eq} = 3C$

Clicker 11-3

Which of the following is NOT necessarily true:

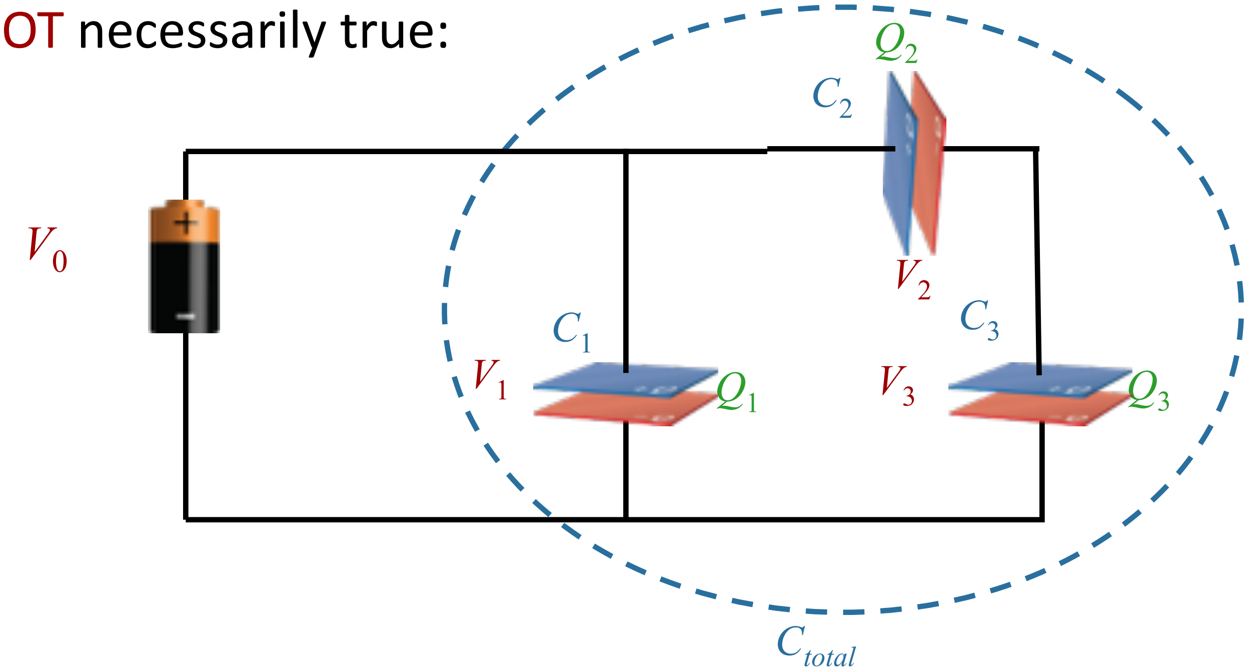
A) $V_0 = V_1$

B) $C_{total} > C_1$

C) $V_2 = V_3$

D) $Q_2 = Q_3$

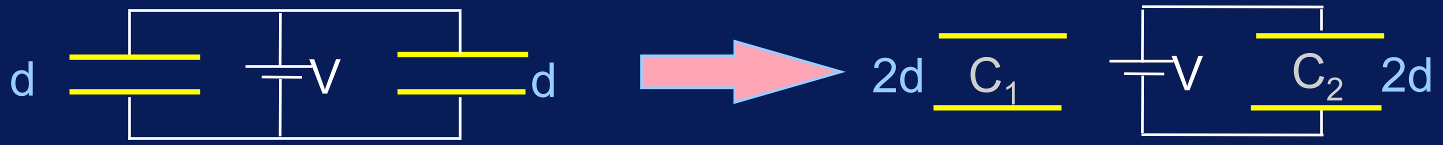
E) $V_1 = V_2 + V_3$



Clicker 11-4

Lecture 12

- Two identical parallel plate capacitors are connected to a battery.
  - C_1 is then disconnected from the battery and the separation between the plates of both capacitors is doubled.



  - What is the relation between U_1, the energy stored in C_1, and U_2, the energy stored in C_2?

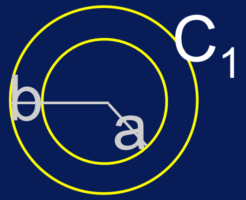
(a) $U_1 < U_2$ (b) $U_1 = U_2$ (c) $U_1 > U_2$ (d) I don't know

Clicker 12-1

Consider two cylindrical capacitors, each of length L.

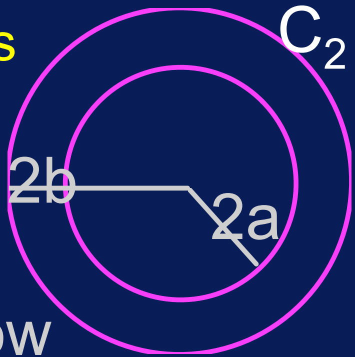
C_1 has inner radius a and outer radius b.

C_2 has inner radius 2a and outer radius 2b.



If both capacitors are given the same amount of charge, what is the relation between U_1, the energy stored in C_1, and U_2, the energy stored in C_2?

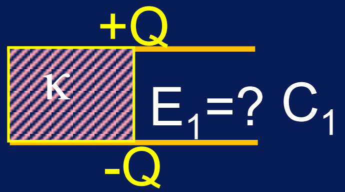
$$C_{Cylinder} = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$$



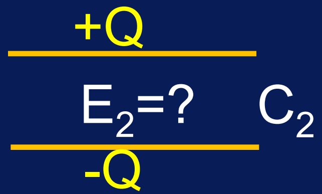
(a) $U_2 < U_1$ (b) $U_2 = U_1$ (c) $U_2 > U_1$ (d) I don't know

Clicker 12-2

- Two parallel plate capacitors are identical except C_1 has half of the space between the plates filled with a material of dielectric constant κ.



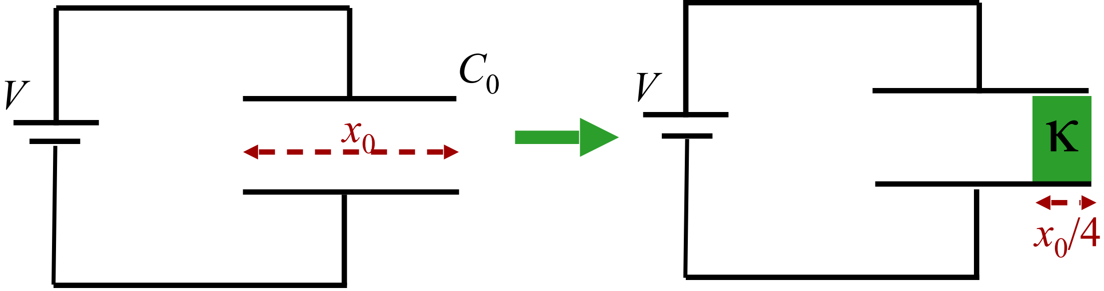
  - Both capacitors have charge Q
  - Compare E_1, the electric field in the air of C_1, to E_2, the electric field in the air of C_2



(a) $E_1 < E_2$ (b) $E_1 = E_2$ (c) $E_1 > E_2$ (d) I don't know

Clicker 12-3

Lecture 13



- An air-gap capacitor, having capacitance C_0 and width x_0 is connected to a battery of voltage V.

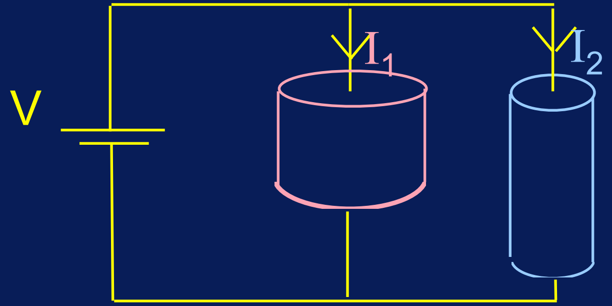
- A dielectric (κ) of width $x_0/4$ is inserted into the gap as shown.

What changes when the dielectric added?

A) Only C B) only Q C) only V D) C and Q E) V and Q F) I Don't Know

Clicker 13-1

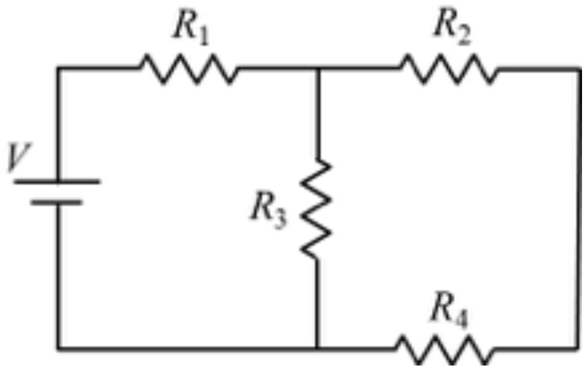
- Two cylindrical resistors, R_1 and R_2, are made of identical material. R_2 has twice the length of R_1 but half the radius of R_1.
  - These resistors are then connected to a battery V as shown:



  - What is the relation between I_1, the current flowing in R_1, and I_2, the current flowing in R_2?

(a) $I_1 = I_2$ (b) $I_1 = 2I_2$ (c) $I_1 = 4I_2$ (d) $I_1 = 8I_2$

Clicker 13-2

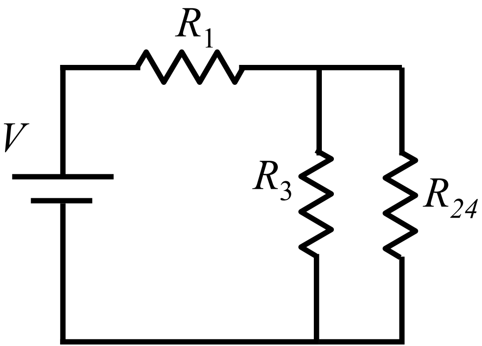


30 second clicker

Combine Resistances: **R_1 and R_2 are connected:**

A) in series B) in parallel C) neither in series nor in parallel

Clicker 13-3



In the circuit shown: V = 18V,

$R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 3\Omega$, and $R_4 = 4\Omega$.

What is V_2, the voltage across R_2?

Combine Resistances: R_2 and R_4 are connected in series = R_{24}

R_3 and R_{24} are connected in parallel = R_{234}

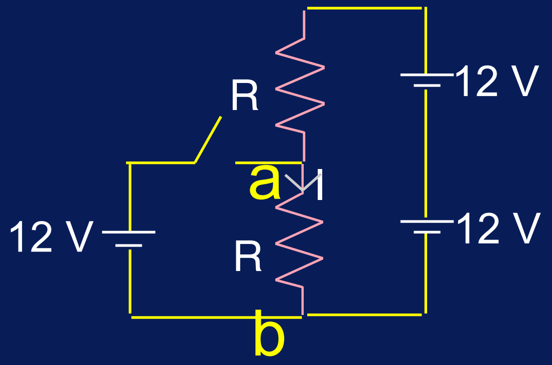
What is the value of R_{234}?

A) $R_{234} = 1\ \Omega$ B) $R_{234} = 2\ \Omega$ C) $R_{234} = 4\ \Omega$ D) $R_{234} = 6\ \Omega$

Clicker 13-4

Lecture 14

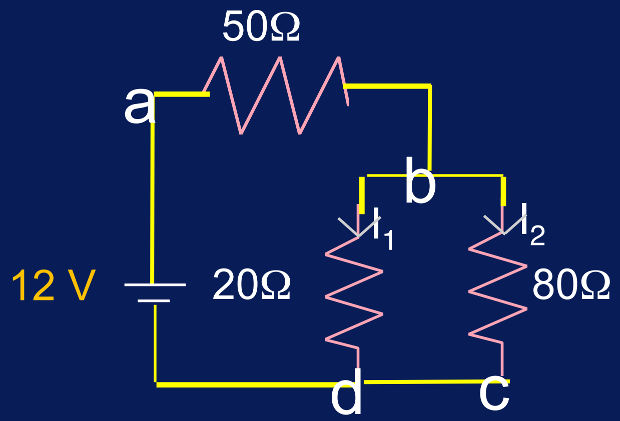
- **Consider the circuit shown.**
  - **The switch is initially open and the current flowing through the bottom resistor is I_0.**
  - **After the switch is closed, the current flowing through the bottom resistor is I_1.**
  - **What is the relation between I_0 and I_1?**



(a) $I_1 < I_0$ (b) $I_1 = I_0$ (c) $I_1 > I_0$

Clicker 14-1

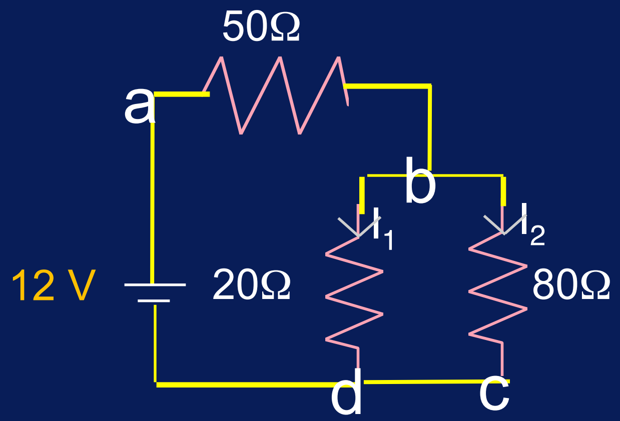
- **Consider the circuit shown:**
  - **What is the relation between $V_a - V_d$ and $V_a - V_c$?**



(a) $(V_a - V_d) < (V_a - V_c)$
(b) $(V_a - V_d) = (V_a - V_c)$
(c) $(V_a - V_d) > (V_a - V_c)$

Clicker 14-2

- Consider the circuit shown:
- What is the relation between I_1 and I_2?



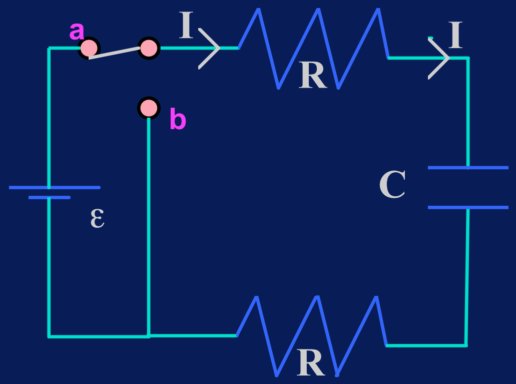
(a) $I_1 < I_2$ (b) $I_1 = I_2$ (c) $I_1 > I_2$

Clicker 14-3

Lecture 15

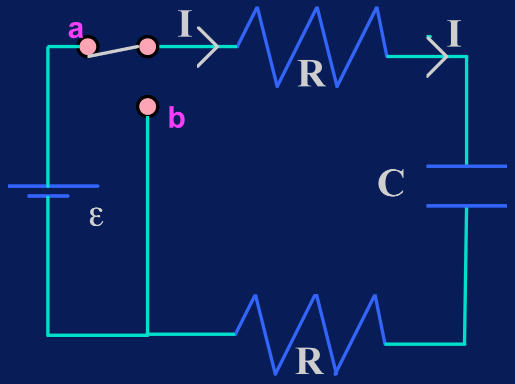
At $t = 0$ the switch is thrown from position b to position a in the circuit shown: The capacitor is initially uncharged.

- What is the value of the current I_0 just after the switch is thrown?



(a) $I_0 = 0$ (b) $I_0 = \varepsilon/2R$ (c) $I_0 = 2\varepsilon/R$

Clicker 15-1

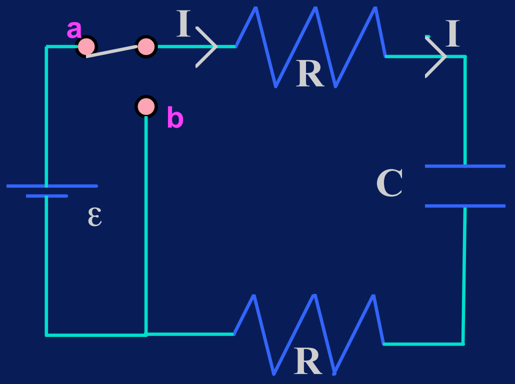


What is the value of the current I_∞ after a very long time?

(a) $I_\infty = 0$ (b) $I_\infty = \varepsilon/2R$ (c) $I_\infty > 2\varepsilon/R$

Clicker 15-2

- At $t = 0$ the switch is thrown from position b to position a in the circuit shown: The capacitor is initially uncharged.
  - At time $t = t_1 = \tau$, the charge Q_1 on the capacitor is $(1-1/e)$ of its asymptotic charge $Q_f = C\varepsilon$.
  - What is the relation between Q_1 and Q_2, the charge on the capacitor at time $t = t_2 = 2\tau$?

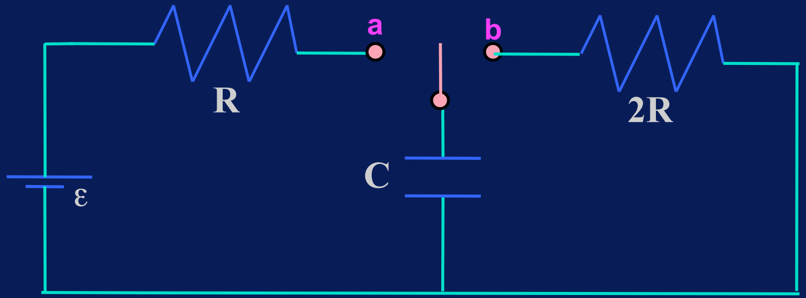


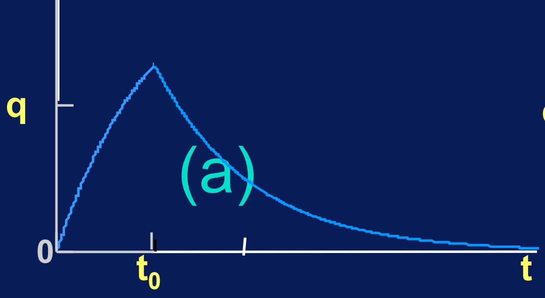
(a) $Q_2 < 2\,Q_1$ (b) $Q_2 = 2\,Q_1$ (c) $Q_2 > 2\,Q_1$

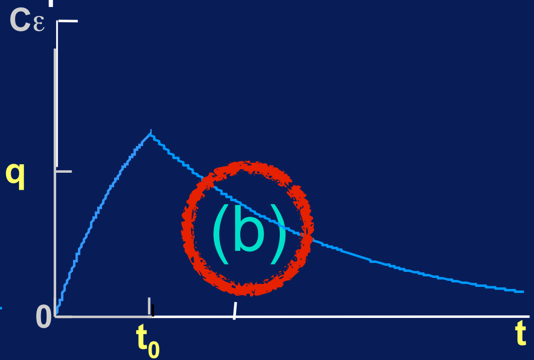
Clicker 15-3

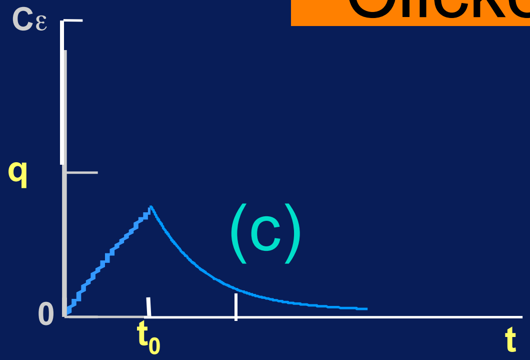
Clicker 15-4

- At $t = 0$ the switch is connected to position a in the circuit shown: The capacitor is initially uncharged.
  - At $t = t_0$, the switch is thrown from position a to position b.
  - Which of the following graphs best represents the time dependence of the charge on C?









Lecture 16 - Review

Lecture 17

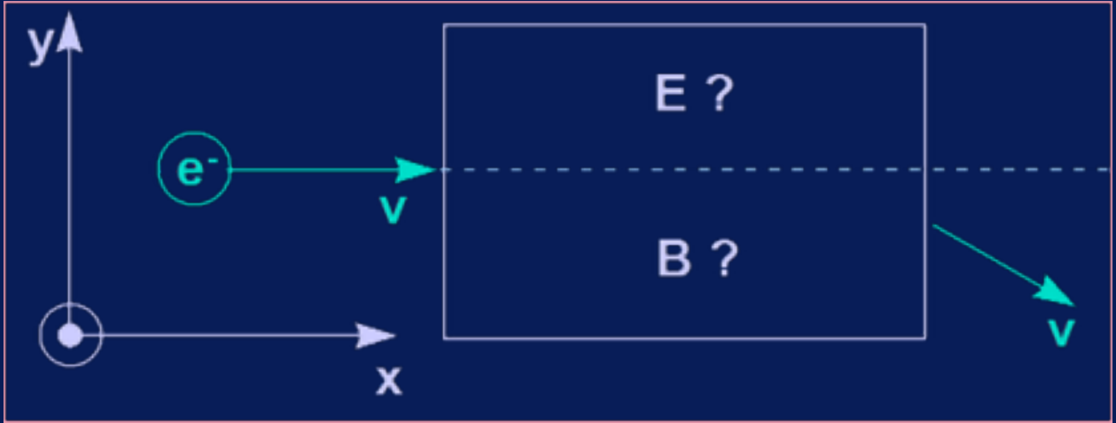
An electron enters a region of space with speed v and exits the region as shown with the same speed (magnitude) v.

From this information, what can we infer about the E_y and B_z fields in the region?

A. Only E_y exists

B. Only B_z exists

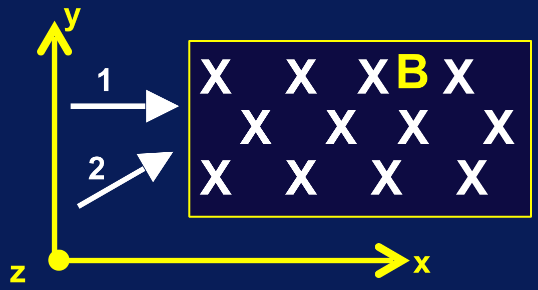
C. Both E_y & B_z can exist



Clicker 17-1

Two protons each move at speed v toward a region of space which contains a constant B field in the –z direction.

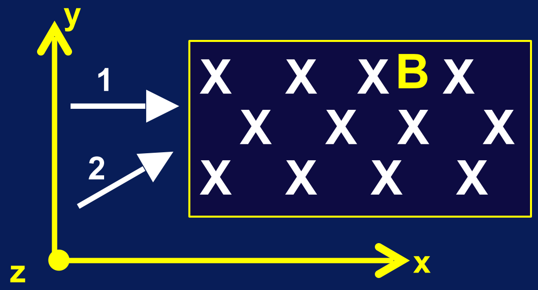
- *What is the relation between the magnitudes of the forces on the two protons in the magnetic field region?*



(a) $F_1 < F_2$ (b) $F_1 = F_2$ (c) $F_1 > F_2$

Clicker 17-2

Two protons each move at speed v toward a region of space which contains a constant B field in the –z direction.



What is F_{2x}, the x-component of the force on the second proton?

(a) $F_{2x} < 0$ (b) $F_{2x} = 0$ (c) $F_{2x} > 0$

Clicker 17-3

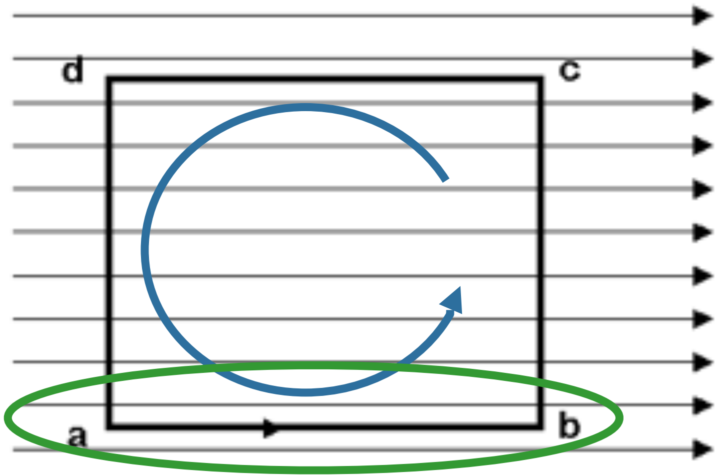
Question about work; Answer = no work, B

Clicker 17-4

Lecture 18

A square loop of wire is carrying current in the counterclockwise direction. A horizontal uniform magnetic field points to the right

C: 18-1

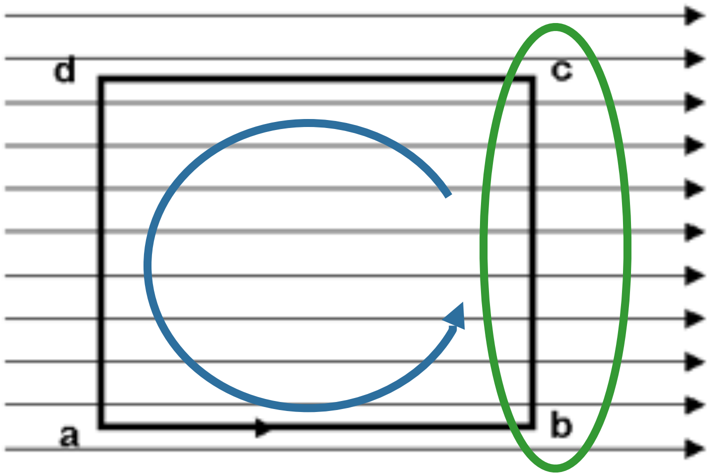


What is the force on section a-b of the loop ?

A) zero B) out of the page C) into the page D) Up E) Down

C: 18-2

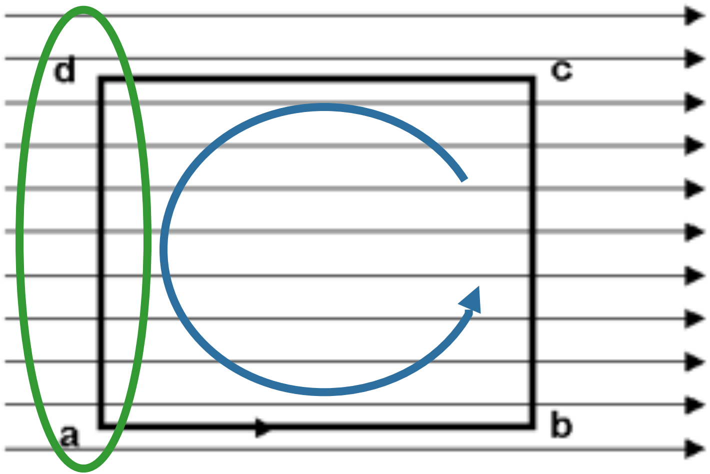
A square loop of wire is carrying current in the counterclockwise direction. A horizontal uniform magnetic field points to the right



What is the force on section b-c of the loop ?

A) zero B) out of the page C) into the page D) Up E) Down

A square loop of wire is carrying current in the counterclockwise direction. A horizontal uniform magnetic field points to the right



What is the force on section d-a of the loop ?

A) zero B) out of the page C) into the page D) Up E) Down

A **current** $\mathbf{I}$ flows in a wire which is formed in the shape of an isosceles triangle as shown. A constant magnetic field exists in the -z direction.

What is F_y, net force on the wire in the y-direction?

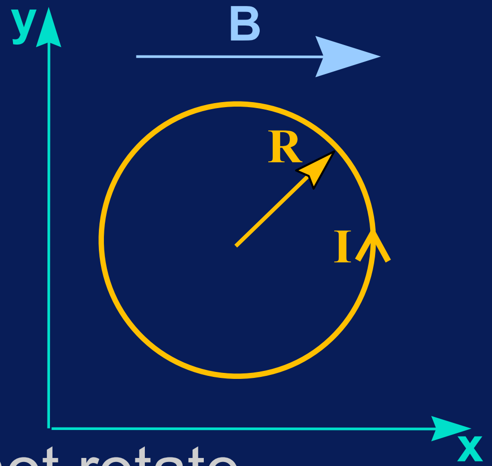
(a) $F_y < 0$

(b) $F_y = 0$

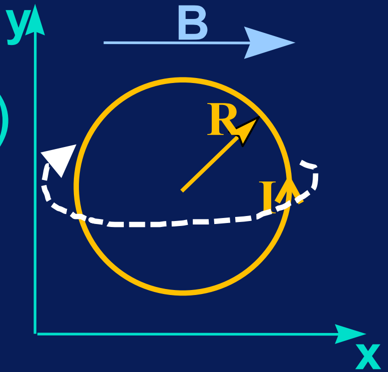
(c) $F_y > 0$

A circular loop of radius R carries current I. A constant magnetic field B exists in the +x direction. Initially the loop is in the x-y plane.

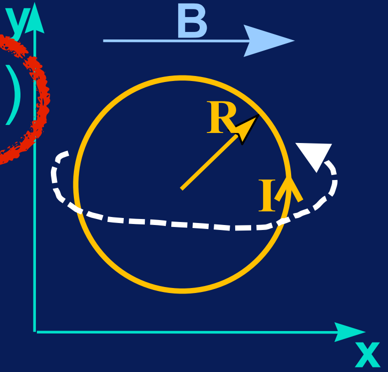
- **How will the coil rotate?**



(a)



(b)

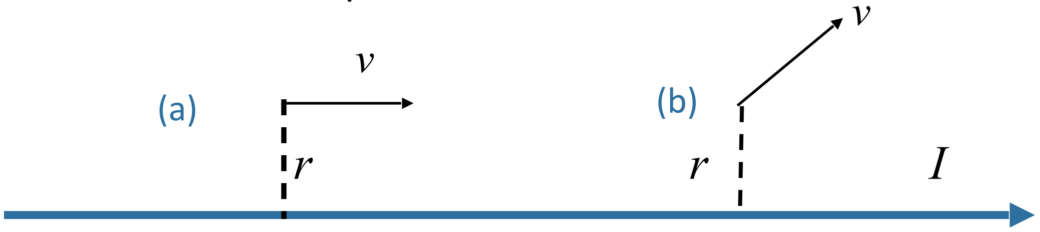


(c) It will not rotate

C: 18-5

Lecture 19

A long straight wire is carrying current from left to right. Two identical charges are moving with equal speed. Compare the magnitude of the force on charge a moving directly to the right, to the magnitude of the force on charge b moving up and to the right at the instant shown (i.e. same distance from the wire).



A) $|F_a| > |F_b|$

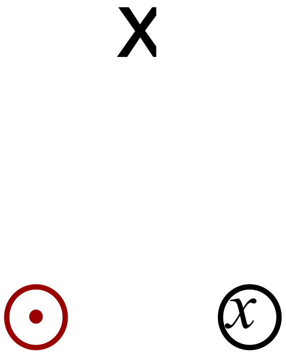
B) $|F_a| = |F_b|$

C) $|F_a| < |F_b|$

C: 19-1

Two long wires carry opposite current

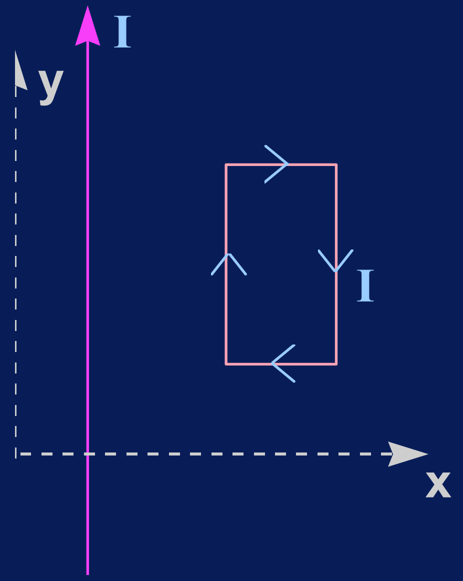
What is the direction of the magnetic field above, and midway between the two wires carrying current – at the point marked “X”?



A) Left B) Right C) Up D) Down E) Zero

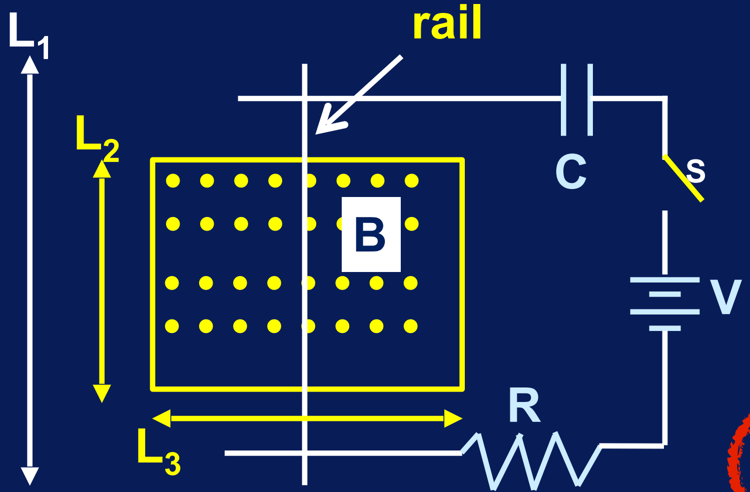
C: 19-2

- A current I flows in the positive y direction in an infinite wire; a current I also flows in the loop as shown in the diagram.
  - What is F_x, net force on the loop in the x-direction?



(a) $F_x < 0$ (b) $F_x = 0$ (c) $F_x > 0$

Lecture 20

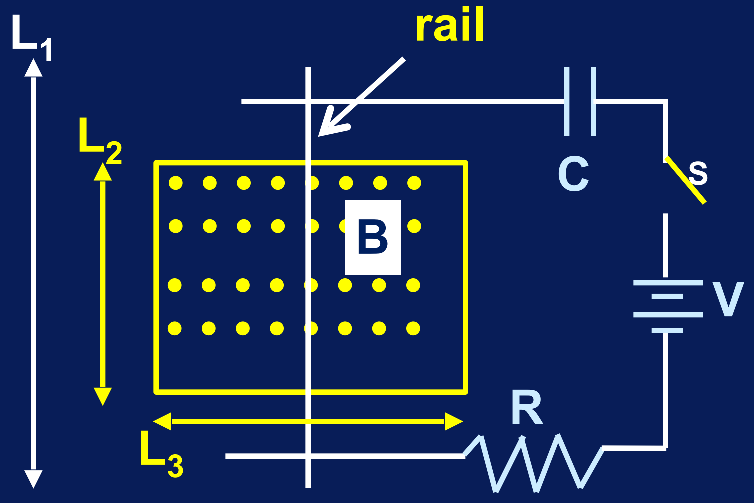


A conducting rail of length L_1 rests on the top of the circuit loop as shown. It is free to move. A uniform magnetic field exists in the box of dimension L_2 by L_3.

When switch s is closed, which way does the rail move (if at all) ?

A) Left
B) Right
C) Rotates clockwise
D) Rotates counterclockwise
E) Does not move

C: 20-1



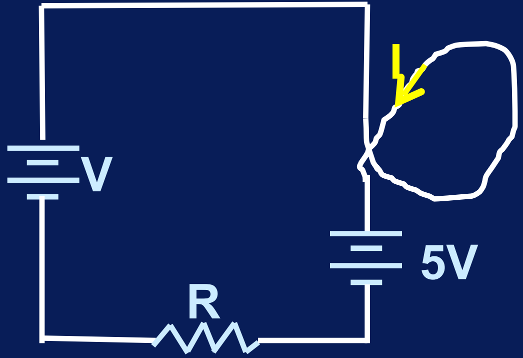
A conducting rail of length L_1 rests on the top of the circuit loop as shown. It is free to move. A uniform magnetic field exists in the box of dimension L_2 by L_3.

What is the magnitude of the force on the rail RC seconds after the switch has been closed?

A) **0.37(V/R)**
B) **0.63(VL_1B)/R**
C) **0.37(VL_1B)/R**
D) **(V/R) L_1L_2B**
E) **0.37(VL_2B)/R**
F) **My answer wasn't listed ☹**

C: 20-2

- A loop of wire is formed in this circuit as shown on the right of the drawing.
- We define the direction of positive current through the loop, +I, as shown



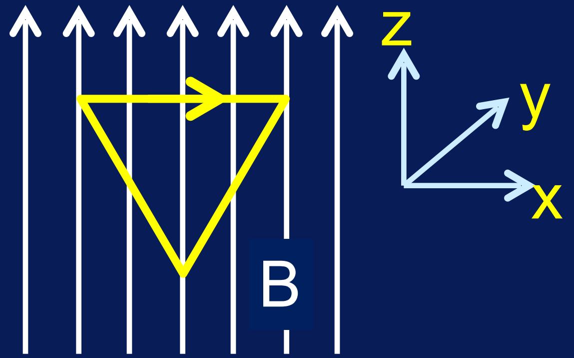
- What is the direction of the magnetic moment and current?

A) I is > 0 & μ is out of the page
B) I is < 0 & μ is out of the page
C) I is > 0 & μ is into the page
D) I is < 0 & μ is into the page

C: 20-3

- Consider the loop of current shown, which is located in a uniform vertical magnetic field.

- About which axis might this loop rotate?

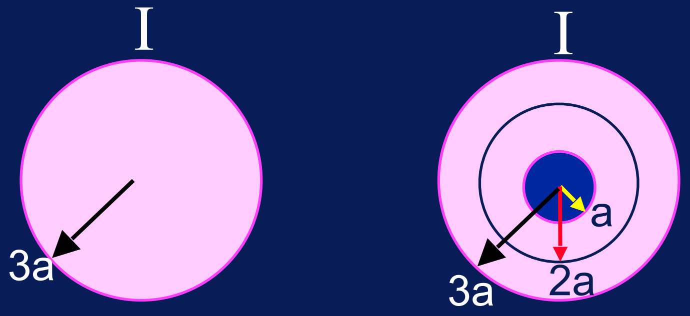


A) **x**
B) **y**
C) **z**
D) **It will not rotate**

C: 20-4

Two cylindrical conductors each carry current I into the screen as shown. The conductor on the left is solid and has radius R = 3a. The conductor on the right has a hole in the middle and carries current only between R = a and R = 3a.

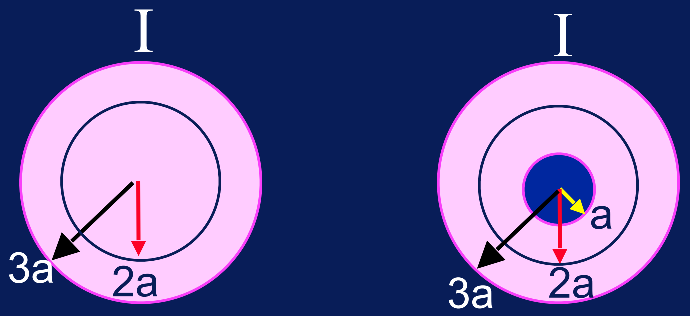
- What is the relation between the magnetic fields at R = 6a for the two cases (L=left, R=right)?



(a) $B_L(6a) < B_R(6a)$ (b) $B_L(6a) = B_R(6a)$ (c) $B_L(6a) > B_R(6a)$

C: 20-5

Two cylindrical conductors each carry current I into the screen as shown. The conductor on the left is solid and has radius R = 3a. The conductor on the right has a hole in the middle and carries current only between R = a and R = 3a.



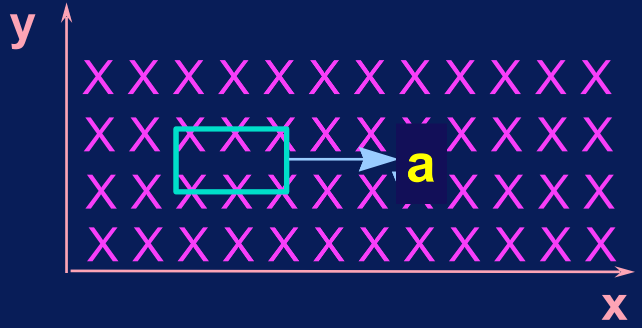
What is the relation between the magnetic field at R = 2a for the two cases (L=left, R=right)? (do the calculation)

(a) $B_L(2a) < B_R(2a)$ (b) $B_L(2a) = B_R(2a)$ (c) $B_L(2a) > B_R(2a)$

C: 20-6

Lecture 21

- A conducting rectangular loop is accelerated in the +x direction through a region of constant magnetic field B in the -z direction as shown.
  - What is the direction of the induced current in the loop?



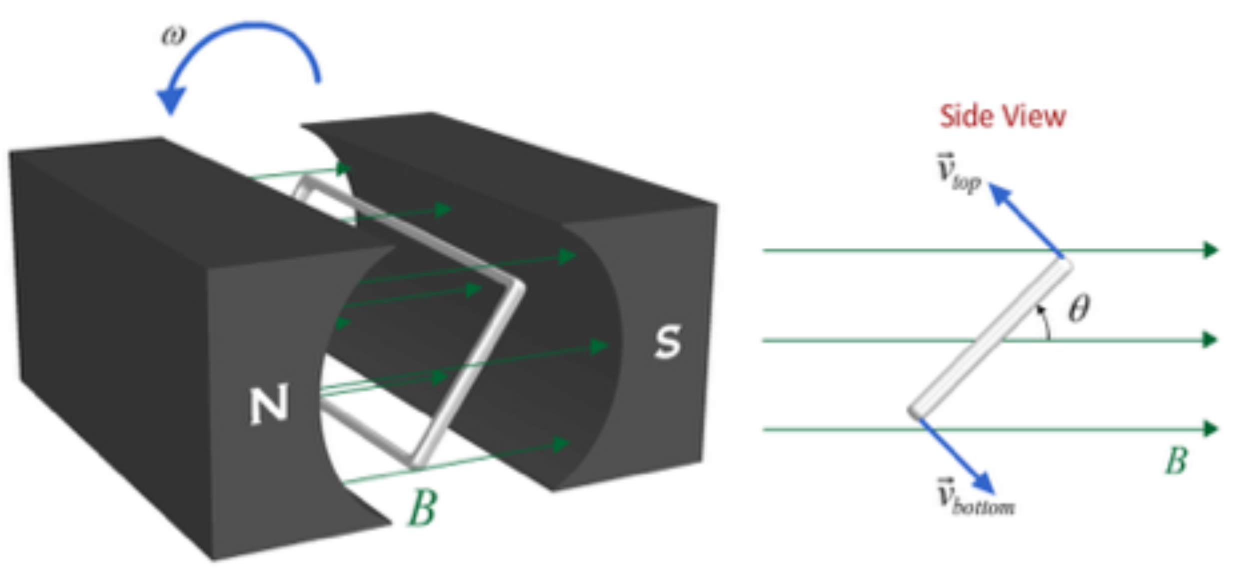
(a) ccw

(b) cw

(c) no induced current

C: 21-1

C: 21-2



At what angle θ is *emf* the largest?

A) θ = 0

B) θ = 45°

C) θ = 90°

D) *emf* is same at all angles

Lecture 22

Suppose you double the magnetic field in a given region and quadruple the area through which this magnetic field exists. The effect on the flux through this area would be to

A. Leave it unchanged
B. Double it
C. Quadruple it
D. Increase by factor of 6
E. Increase it by factor of 8

C: 22-1

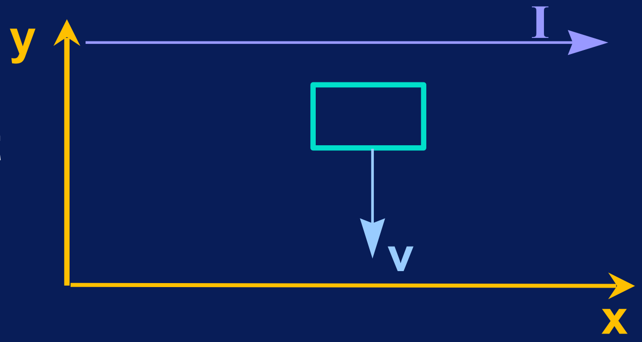
A 3.0-cm by 5.0-cm rectangular coil has 100 turns. Its axis makes an angle of 55º with a uniform magnetic field of 0.35 T. What is the magnetic flux through this coil?

A. 3.0×10^{-4} Wb
B. 4.3×10^{-4} Wb
C. 3.0×10^{-2} Wb
D. 4.3×10^{-2} Wb
E. 5.3×10^{-2} Wb

C: 22-2

A conducting rectangular loop moves with constant velocity v in the -y direction and a constant current I flows in the +x direction as shown.

What is the direction of the induced current in the loop?

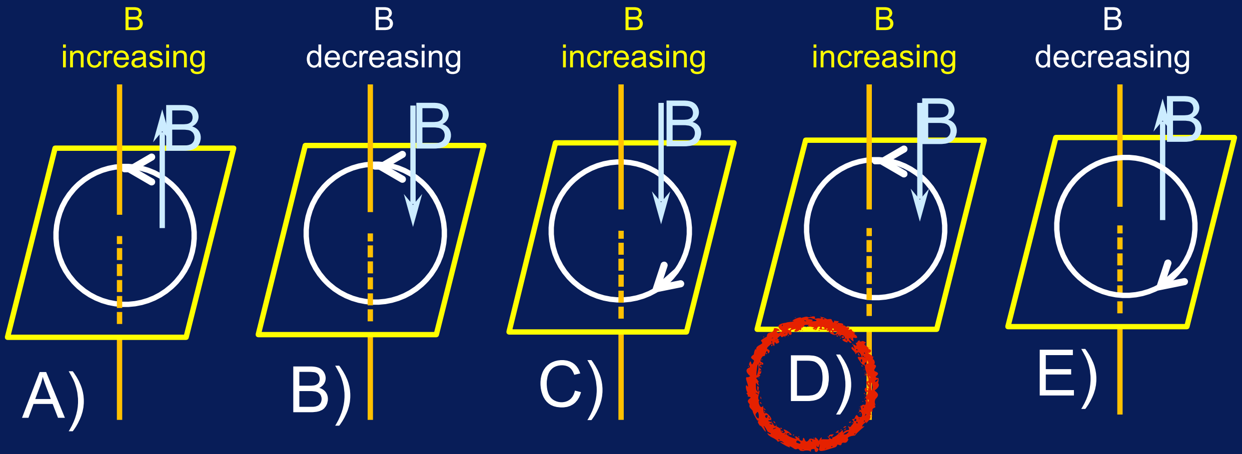


(a) ccw

(b) cw

(c) no induced current

A loop rests in the *xy* plane. The *z* axis is normal to the plane. The direction of the changing flux is indicated by the arrow on the *z* axis. The diagram that correctly shows the direction of the resultant induced current in the loop is

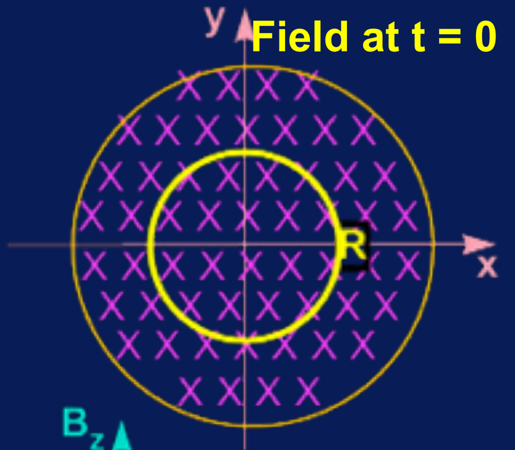


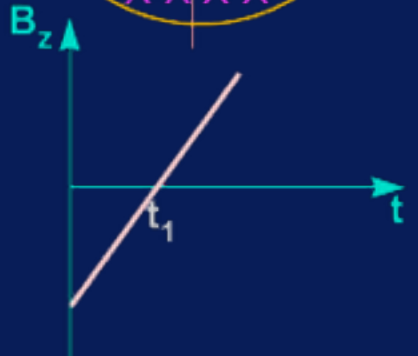
C: 22-4

Lecture 23

The magnetic field in a region of space of radius 2R is aligned with the z-direction and changes in time as shown in the plot.

Which way would the induced current flow in yellow loop at time $t=t_1$?

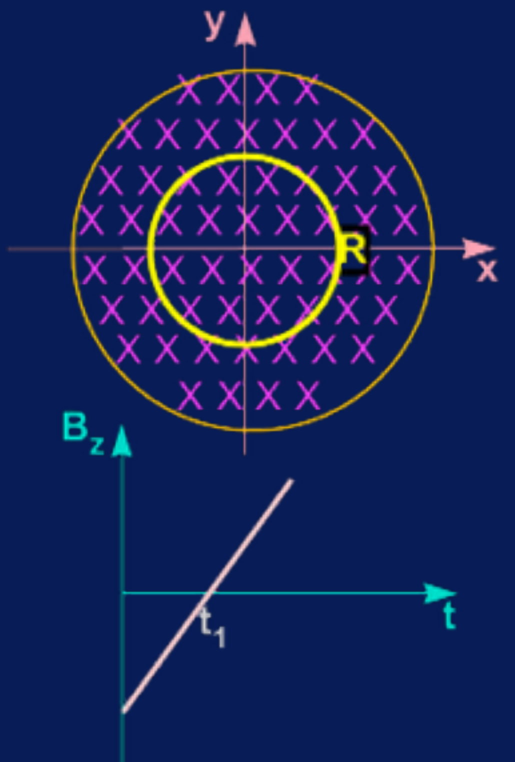




(a) ccw (b) cw (c) No current

C: 23-1

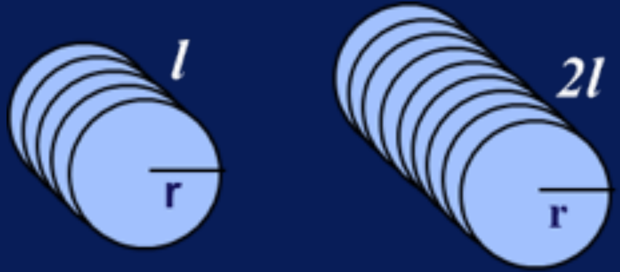
What is the relation between the magnitudes of the induced electric fields E_R at radius R and E_{2R} at radius 2R ?



(a) $E_{2R} = E_R$ (b) $E_{2R} = 2E_R$ (c) $E_{2R} = 4E_R$

C: 23-2

- Consider the two inductors shown:
  - Inductor 1 has length l, N total turns and has inductance L_1.
  - Inductor 2 has length $2l$, 2N total turns and has inductance L_2.
  - What is the relation between L_1 and L_2?



N turns

2N turns

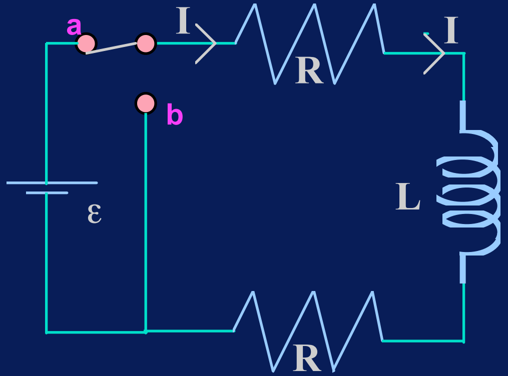
(a) $L_2 < L_1$

(b) $L_2 = L_1$

(c) $L_2 > L_1$

C: 23-3

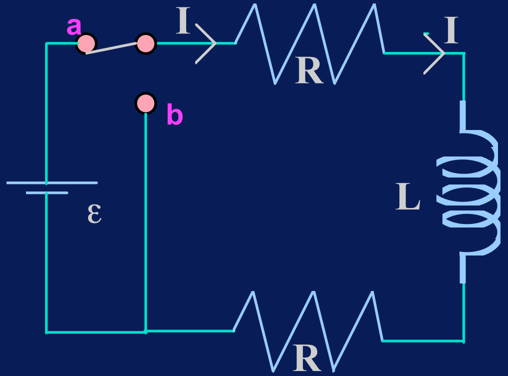
- **At $t = 0$ the switch is thrown from position b to position a in the circuit shown:**
  - **What is the value of the current I_∞ a long time after the switch is thrown?**



(a) $I_\infty = 0$ (b) $I_\infty = \varepsilon / 2R$ (c) $I_\infty = 2\varepsilon / R$

C: 23-4

What is the value of the current I_0 immediately after the switch is thrown?



(a) $I_0 = 0$ (b) $I_0 = \varepsilon / 2R$ (c) $I_0 = 2\varepsilon / R$

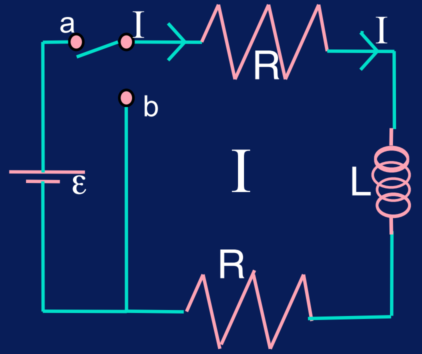
C: 23-5

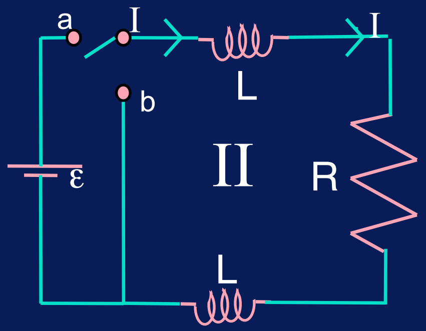
Lecture 24

At t=0, the switch is thrown from position b to position a as shown:

- Let t_{I} be the time for circuit I to reach 1/2 of its asymptotic current.
- Let t_{II} be the time for circuit II to reach 1/2 of its asymptotic current.
- What is the relation between t_{I} and t_{II}?

(a) $t_{II} < t_{I}$ (b) $t_{II} = t_{I}$ (c) $t_{II} > t_{I}$



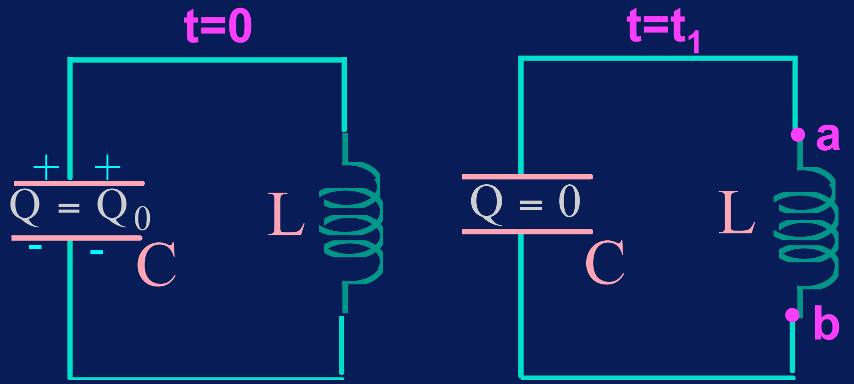


C: 24-1

Lecture 25

At $t=0$, the capacitor in the LC circuit shown has a total charge Q_0. At $t = t_1$, the capacitor is uncharged.

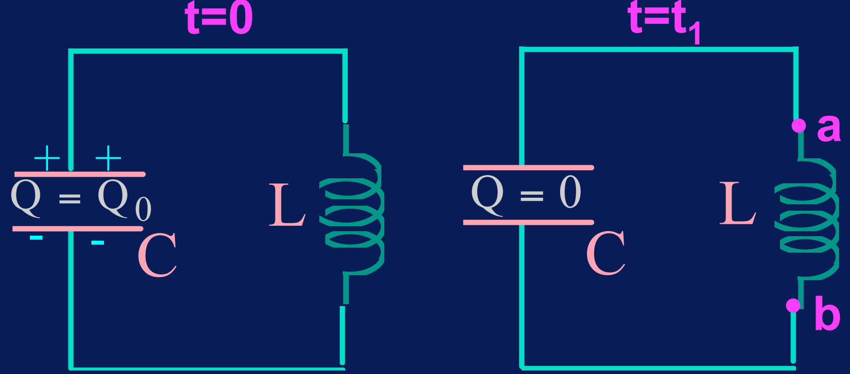
- What is the value of V_{ab}, the voltage across the inductor at time t_1?



(a) $V_{ab} < 0$ (b) $V_{ab} = 0$ (c) $V_{ab} > 0$

C: 25-1

At t=0, the capacitor in the LC circuit shown has a total charge Q_0. At $t = t_1$, the capacitor is uncharged.



What is the relation between U_{L1}, the energy stored in the inductor at $t = t_1$, and U_{C1} , the energy stored in the capacitor at $t = t_1$?

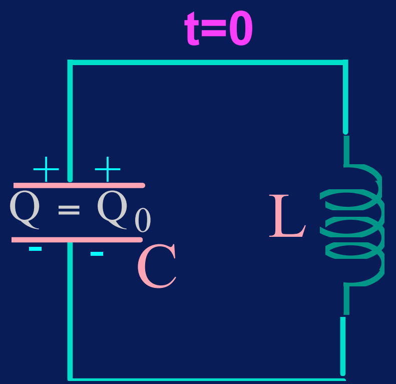
(a) $U_{L1} < U_{C1}$

(b) $U_{L1} = U_{C1}$

(c) $U_{L1} > U_{C1}$

C: 25-2

At $t = 0$ the capacitor has charge Q_0; the resulting oscillations have frequency ω_0. The maximum current in the circuit during these oscillations has value I_0 .



- What is the relation between ω_0 and ω_2 , the frequency of oscillations when the initial charge = $2Q_0$?

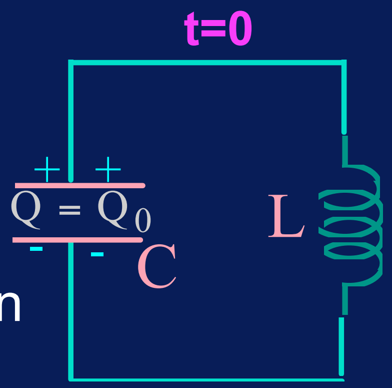
(a) $\omega_2 = 1/2\ \omega_0$

(b) $\omega_2 = \omega_0$

(c) $\omega_2 = 2\ \omega_0$

C: 25-3

- **At t = 0 the capacitor has charge Q_0; the resulting oscillations have frequency ω_0. The maximum current in the circuit during these oscillations has value I_0 .**



What is the relation between I_0 and I_2 , the maximum current in the circuit when the initial charge = $2Q_0$?

(a) $I_2 = I_0$

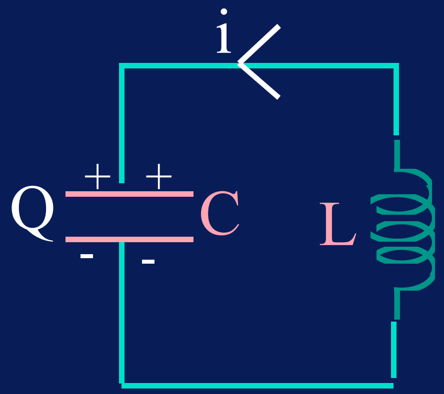
(b) $I_2 = 2\ I_0$

(c) $I_2 = 4\ I_0$

C: 25-4

At $t = 0$ the current flowing through the circuit is 1/2 of its maximum value.

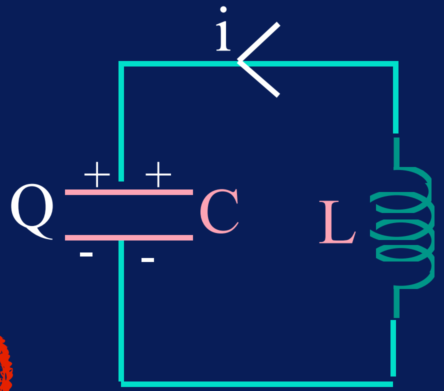
- **Which of the following is a possible value for the phase ϕ, when the charge on the capacitor is described by: $Q(t) = Q_0\cos(\omega t + \phi)$.**

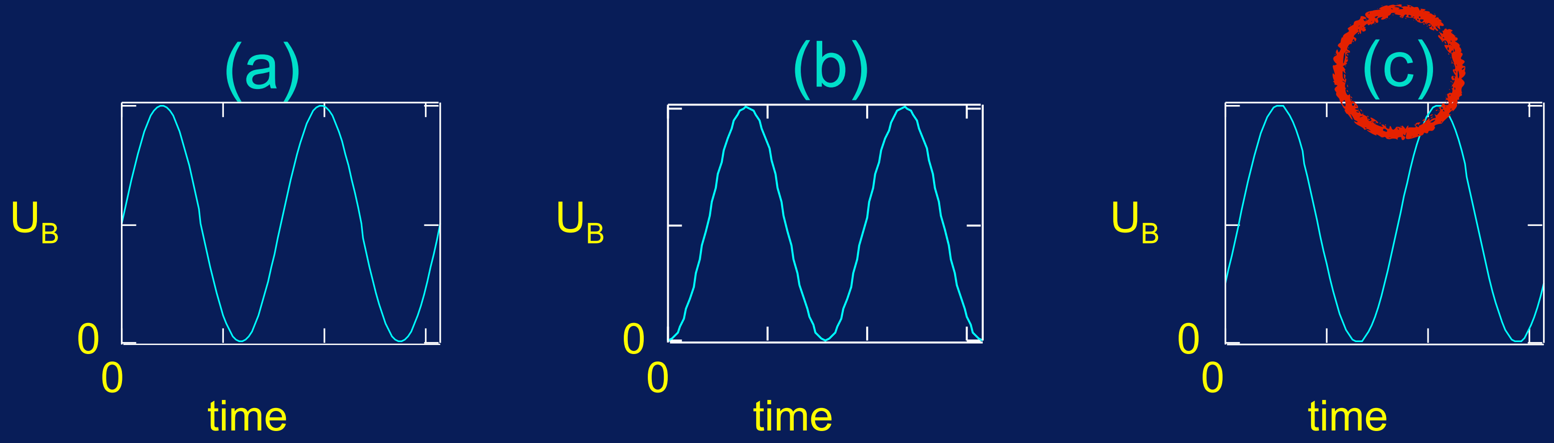


(a) $\phi = 30°$ (b) $\phi = 45°$ (c) $\phi = 60°$

Lecture 26

- At t = 0 the current flowing through the circuit is 1/2 of its maximum value.
  - Which of the following plots best represents U_B, the energy stored in the inductor as a function of time ?



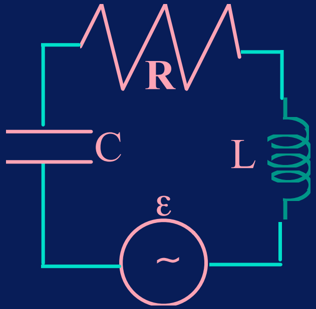


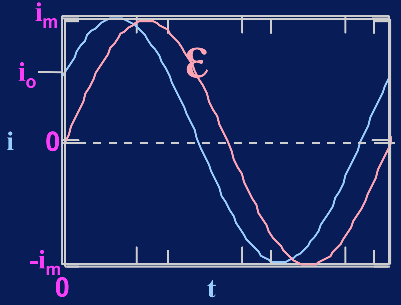
C: 26-1

$X_L \equiv \omega L \qquad X_C \equiv \dfrac{1}{\omega C}$

Series LCR circuit is driven by a generator with $\varepsilon = \varepsilon_m \sin\omega t$. The time dependence of the current i which flows in the circuit is shown in the plot.

- **How should ω be changed to bring the current and driving voltage into phase?**



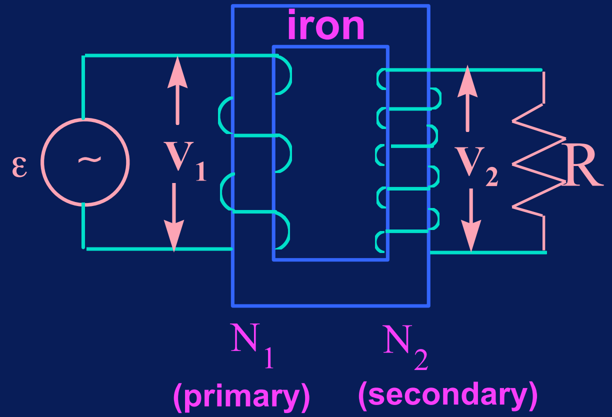


(a) increase ω (b) decrease ω (c) impossible

C: 26-2

Lecture 27

- The primary coil of an ideal transformer is connected to an AC voltage source as shown. There are 50 turns in the primary and 200 turns in the secondary.
  - If V_1 = 120 V, what is the potential drop across the resistor R ?



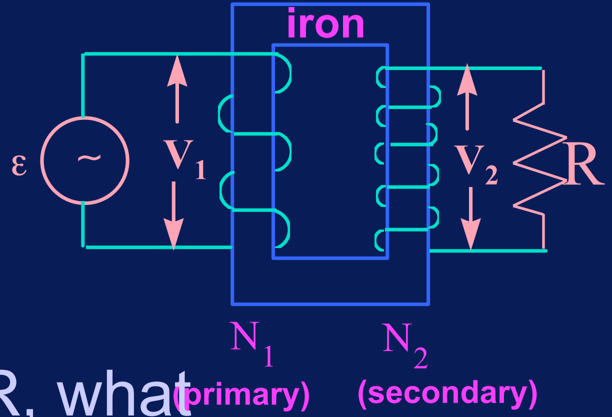
(a) 30 V

(b) 120 V

(c) 480 V

C: 27-1

- **The primary coil of an ideal transformer is connected to an AC voltage source as shown. There are 50 turns in the primary and 200 turns in the secondary.**

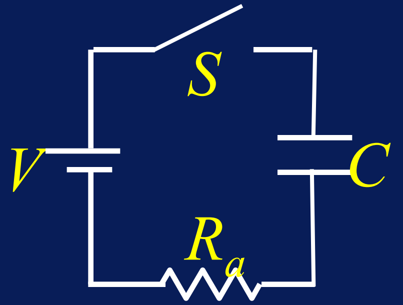


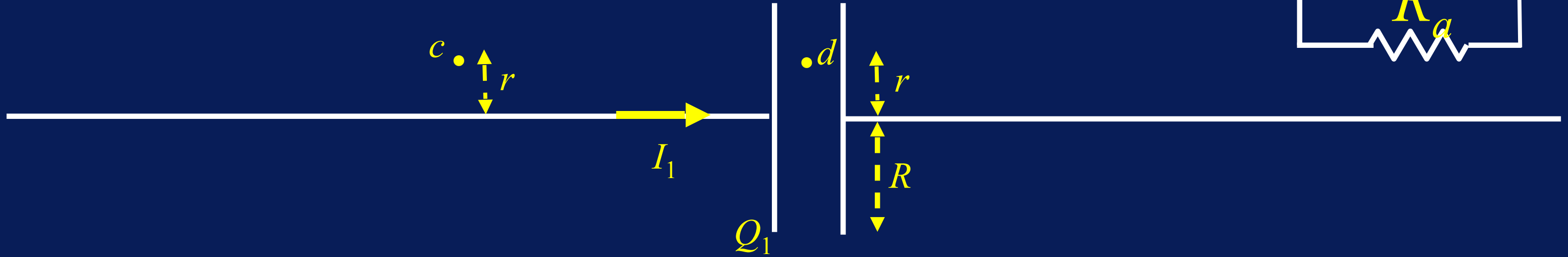
  – If 960 W are dissipated in the resistor R, what is the current in the primary ?

(a) 8 A (b) 16 A (c) 32 A

C: 27-2

At t = 0, switch is closed. Capacitor C has circular plates of radius R. At t = t_1, a current I_1 flows in the circuit and the capacitor carries charge Q_1.





Compare the magnitudes of the B fields at points c and d.

A) $B_c < B_d$ B) $B_c = B_d$ C) $B_c > B_d$

C: 27-3