

PHYS 1004: INTRODUCTORY ELECTROMAGNETISM AND WAVE MOTION

Term Test # 2: Gauss' Law and Electric Potential

VERSION 1

Duration: 30 minutes

Name _____

Allowed aids: Calculator, Ruler

Reference material provided on separate sheet

Student Number _____

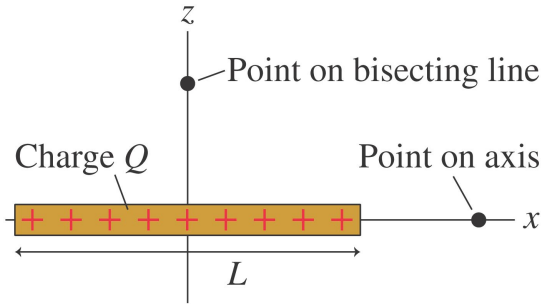
- Complete both problems which have been selected from and based on those twenty problems assigned in the tutorials.
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 - Both problems are weighted equally.
1. A $3.0 \text{ cm} \times 3.0 \text{ cm}$ rectangle lies in the xy -plane. What is the electric flux through the rectangle if there is an electric field of $\vec{E} = (50 \hat{i} + 30 \hat{k}) \text{ N/C}$?
- a) $0.045 \text{ Nm}^2/\text{C}$
 - b) $0.027 \text{ Nm}^2/\text{C}$
 - c) $0.060 \text{ Nm}^2/\text{C}$
 - d) $0 \text{ Nm}^2/\text{C}$

2. The figure below shows a thin rod of length L and charge Q . Find an expression for the electric potential a distance x away from the centre of the rod on the axis of the rod.

Hint: You may find the following standard integrals useful:

$$\int \frac{dx}{\sqrt{x^2 + d^2}} = \ln \left(x + \sqrt{x^2 + d^2} \right) + \text{constant}, \quad \int \frac{dx}{x + d} = \ln |x + d| + \text{constant}$$

where d is the distance of the point away from the line of charge.



a) $V(x) = \frac{Q}{4\pi\epsilon_0 L} \ln \left| \frac{2x+L}{2x-L} \right|$

b) $V(x) = \frac{Q}{4\pi\epsilon_0 L}$

c) $V(x) = \frac{Q}{4\pi\epsilon_0 x}$

d) $V(x) = \frac{Q}{4\pi\epsilon_0 L} \ln \left(\frac{L + \sqrt{L^2 + 4x^2}}{-L + \sqrt{L^2 + 4x^2}} \right)$

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1. A spark occurs at the tip of a needle if the electric field strength exceeds 25.0×10^6 N/C. What is the minimum surface charge density for producing a spark?
- a) 1.76×10^{-5} C/m²
 - b) 2.65×10^{-5} C/m²
 - c) 2.21×10^{-4} C/m²
 - d) 25.0×10^6 C/m²

2. A $+4.0$ nC charge is at $x = 0$ cm and a -2.0 nC charge is at $x = 8.0$ cm. At what point or points on the x -axis is the electric potential zero?
- a) $x = 5.3$ cm
 - b) $x = 5.3$ cm and $x = 16$ cm**
 - c) $x = -16$ cm
 - d) $x = 3.0$ cm and $x = 6.0$ cm

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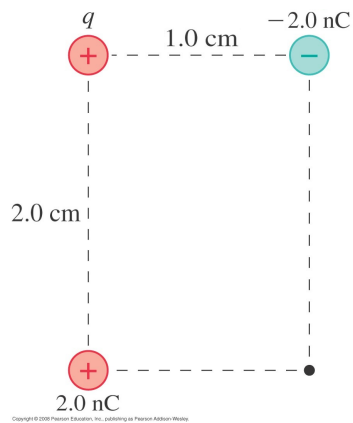
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1. A 15 nC point charge is at the centre of a 3.0 m × 3.0 m × 3.0 m cube. What is the total electric flux through the top and bottom surfaces of the cube?
- a) $5.6 \times 10^2 \text{ Nm}^2/\text{C}$
 - b) $2.8 \times 10^2 \text{ Nm}^2/\text{C}$
 - c) $1.9 \times 10^2 \text{ Nm}^2/\text{C}$
 - d) $1.7 \times 10^3 \text{ Nm}^2/\text{C}$

2. The electric potential at the dot in the figure below is 1570 V. What is the charge q ?



- a) 3.9 nC
b) 2.8 nC
c) 1.7 nC
d) 10 nC

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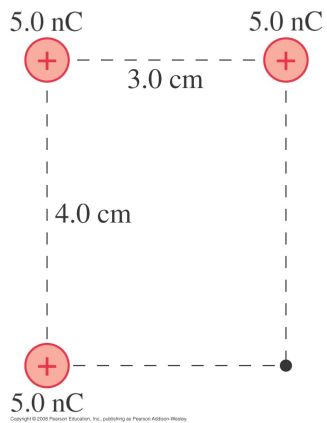
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1. A spherically symmetric charge distribution produces the electric field $\vec{E} = (150/r^2) \hat{r}$ N/C, where r is in m. What is the electric flux through a 10-cm-diameter spherical surface that is concentric with the charge distribution and how much charge is inside this surface?

- a) $\Phi = 1.2 \times 10^2$ Nm²/C, $Q = 11$ nC
- b) $\Phi = 1.9 \times 10^4$ Nm²/C, $Q = 170$ nC
- c) $\Phi = 3.8 \times 10^3$ Nm²/C, $Q = 34$ nC
- d) $\Phi = 1.9 \times 10^3$ Nm²/C, $Q = 17$ nC

2. What is the electric potential at the point indicated with the dot in the figure below?



a) 3500 V

b) 1400 V

c) 1100 V

d) 900 V

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1. A neutral conductor contains a hollow cavity in which there is a -150 nC point charge. A charged rod then transfers $+80 \text{ nC}$ to the conductor. Afterward, what is the charge on the inner wall of the cavity wall (Q_{in}) and the charge on the exterior surface of the conductor (Q_{out})?

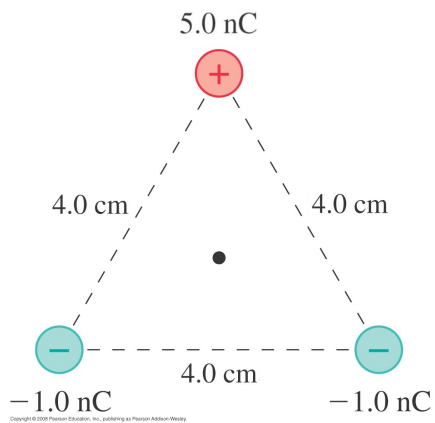
a) $Q_{in} = -150 \text{ nC}$, $Q_{out} = +80 \text{ nC}$

b) $Q_{in} = -100 \text{ nC}$, $Q_{out} = +50 \text{ nC}$

c) $Q_{in} = +150 \text{ nC}$, $Q_{out} = -70 \text{ nC}$

d) $Q_{in} = 0 \text{ nC}$, $Q_{out} = -70 \text{ nC}$

2. What is the electric potential at the centre of the equilateral triangle formed by the three charges, indicated with the dot, in the figure below?



- a) 0 V
- b) 670 V
- c) 2700 V
- d) 1200 V**

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1. A 30-cm-diameter ball is uniformly charged to 100 nC. How much charge is enclosed by a sphere of radius 10 cm and what is the electric field strength at a point 10 cm from the centre?

a) $Q_{enc} = 44 \text{ nC}$, $E = 40 \text{ kN/C}$

b) $Q_{enc} = 3.7 \text{ nC}$, $E = 3.3 \text{ kN/C}$

c) $Q_{enc} = 100 \text{ nC}$, $E = 90 \text{ kN/C}$

d) $Q_{enc} = 30 \text{ nC}$, $E = 27 \text{ kN/C}$

2. A 5.0-cm-diameter parallel-plate capacitor has a 2.5 mm spacing. The electric field strength inside the capacitor is 2.2×10^5 V/m. What is the potential difference across the capacitor, and how much charge is on each plate?

a) $\Delta V = 200$ V, $Q = 2.5$ nC

b) $\Delta V = 200$ V, $Q = 0.62$ nC

c) $\Delta V = 550$ V, $Q = 3.8$ nC

d) $\Delta V = 550$ V, $Q = 15$ nC

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1. A hollow metal sphere has 4 cm and 8 cm inner and outer radii, respectively. Due to an unknown point charge at the centre of the sphere, the surface charge density on the inside surface is -50 nC/m^2 and the surface charge density on the exterior surface is $+50 \text{ nC/m}^2$. What are electric field strengths at points 2 cm and 10 cm from the centre?

a) $E(2 \text{ cm}) = 22 \text{ kN/C}$, $E(10 \text{ cm}) = 3.6 \text{ kN/C}$

b) $E(2 \text{ cm}) = 112 \text{ kN/C}$, $E(10 \text{ cm}) = 45 \text{ kN/C}$

c) $E(2 \text{ cm}) = 22 \text{ kN/C}$, $E(10 \text{ cm}) = 0.91 \text{ kN/C}$

d) $E(2 \text{ cm}) = 0$, $E(10 \text{ cm}) = 45 \text{ kN/C}$

2. What is the speed of an electron ($m_e = 9.1094 \times 10^{-31}$ kg) that has been accelerated from rest through a potential difference of 500 V?

a) 1.3×10^7 m/s

b) 1.9×10^7 m/s

c) 9.4×10^6 m/s

d) 1.4×10^6 m/s

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1. A long, thin straight wire with linear charge density $\frac{\lambda}{2}$ runs down the centre of a thin, hollow metal cylinder of radius R . The cylinder has a net linear charge density of 3λ . Assume λ is positive. Find expressions for the electric field strength inside the cylinder, $r < R$, and outside the cylinder, $r > R$.

a) $\vec{E}(r < R) = \frac{\lambda}{2\pi\epsilon_0 r} \hat{r}$, $\vec{E}(r > R) = \frac{3\lambda}{2\pi\epsilon_0 r} \hat{r}$

b) $\vec{E}(r < R) = \frac{\lambda}{4\pi\epsilon_0 r} \hat{r}$, $\vec{E}(r > R) = \frac{7\lambda}{4\pi\epsilon_0 r} \hat{r}$

c) $\vec{E}(r < R) = \frac{\lambda}{4\pi\epsilon_0 r} \hat{r}$, $\vec{E}(r > R) = \frac{3\lambda}{2\pi\epsilon_0 r} \hat{r}$

d) $\vec{E}(r < R) = \frac{\lambda}{2\pi\epsilon_0 r} \hat{r}$, $\vec{E}(r > R) = \frac{7\lambda}{2\pi\epsilon_0 r} \hat{r}$

2. The electric field strength is 20,000 N/C inside a parallel-plate capacitor with a 1.0 mm spacing. A proton ($m_p = 1.6726 \times 10^{-27}$ kg) is released from rest at the positive plate. What is the proton's speed when it reaches the negative plate?

a) 1.4×10^5 m/s

b) 6.2×10^4 m/s

c) 4.4×10^4 m/s

d) 2.0×10^6 m/s