

End of Term 1 Exam

Program	ATHS	Date	00-00-2022
Grade Stream	12 ADV	Time	09:00 - 10:30 90 mins
Subject Code	Physics PHY71	Section	
Student Name		Student #	

Section (mark)	Mark	1 st Marker	2 nd Marker
I	45		
II	55		
Total	100		

Instructions

- Scientific calculators are allowed.
- Always show all your work (including equations) when solving problems in free response questions and present your answer to the correct number of significant figures and appropriate units.

3. Use if required:

- Proton mass (m_p) = $1.67 \times 10^{-27} \text{ kg}$
- Electron mass (m_e) = $9.11 \times 10^{-31} \text{ kg}$
- Fundamental charge (e) = $1.6 \times 10^{-19} \text{ C}$
- Coulomb's constant (k) = $9.0 \times 10^9 \text{ Nm}^2/\text{C}^2$
- Permittivity of free space (ϵ_0) = $8.85 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$
- General Calculus Equations:**

$$\frac{df}{dx} = \frac{df}{du} \frac{du}{dx}$$

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

$$\frac{d}{dx}(e^{ax}) = ae^{ax}$$

$$\frac{d}{dx}(\ln ax) = \frac{1}{x}$$

$$\frac{d}{dx}[\sin(ax)] = a \cos(ax)$$

$$\frac{d}{dx}[\cos(ax)] = -a \sin(ax)$$

$$\int x^n dx = \frac{1}{n+1} x^{n+1}, n \neq -1$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax}$$

$$\int \frac{dx}{x+a} = \ln|x+a|$$

$$\int \cos(ax) dx = \frac{1}{a} \sin(ax)$$

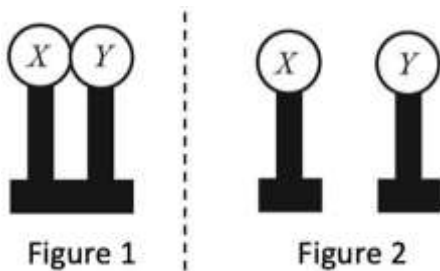
$$\int \sin(ax) dx = -\frac{1}{a} \cos(ax)$$



I. Choose the best answer.

[45 marks; 3 each]

1. A metal sphere X , has an initial charge of -8 nC and an identical sphere Y , has an initial charge of $+6\text{ nC}$. The spheres are made to touch each other and then separated.



What is the net charge on sphere Y after separation and the type of charging method used here?

	Net charge on Y	Type of Charging
A.	-1 nC	conduction
B.	-2 nC	conduction
C.	-1 nC	induction
D.	-2 nC	induction

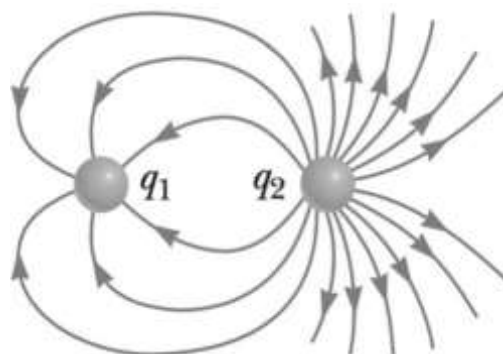
2. A negatively charged rod is brought close to a charged electroscope.



What is the charge on the electroscope if either the leaves fall or the leaves move apart?

	Leaves fall (get closer)	Leaves move apart
A.	negative	negative
B.	negative	positive
C.	positive	negative
D.	positive	positive

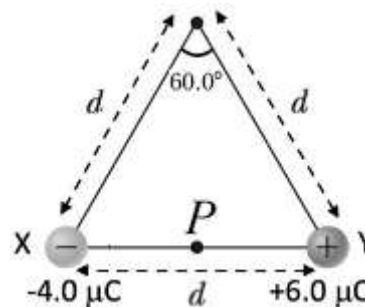
3. The spatial distribution of the electric field due to charges q_1 and q_2 is shown in the figure below.



Which of the parameters regarding the charges are correct?

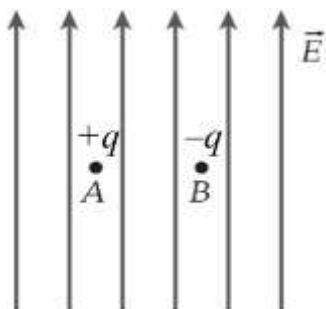
	Charge q_1	Charge q_2	Magnitude
A.	positive	negative	$q_1 > q_2$
B.	positive	negative	$q_2 > q_1$
C.	negative	positive	$q_1 > q_2$
D.	negative	positive	$q_2 > q_1$

4. Charge X with magnitude of $-4.0\text{ }\mu\text{C}$ and charge Y with a magnitude $+6.0\text{ }\mu\text{C}$ are located at the base of an equilateral triangle, as shown in the figure. At point P , determine the ratio of the electric field of charge X and charge Y , $\frac{E_X}{E_Y}$.



- A. $3/2$
 B. $2/3$
 C. $\sqrt{6}/4$
 D. $4/\sqrt{5}$

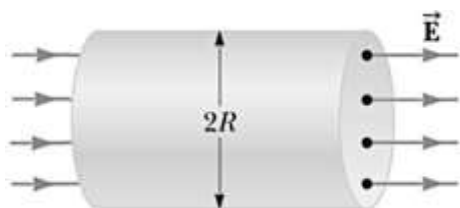
5. Two small charges, $+q$ and $-q$ are placed in a uniform electric field, at point's A and B respectively as shown below.



Compare the magnitude and direction of the electric forces acting on the charges.

	Magnitude of the electric force	Direction of the electric force
A.	Different magnitude	Same direction
B.	Different magnitude	Opposite direction
C.	Same magnitude	Same direction
D.	Same magnitude	Opposite direction

6. The figures below show the electric field lines through a cylinder. What is the net electric flux through the closed cylindrical surface?

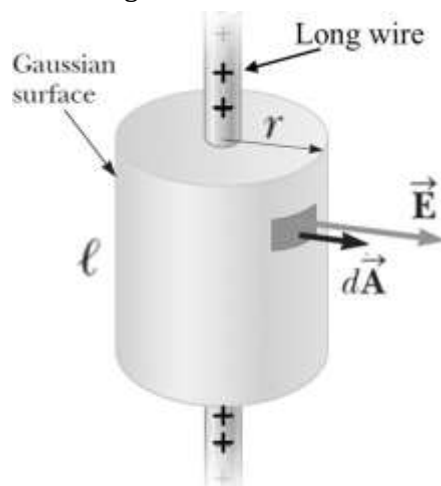


- A. 0
- B. $\pi R^2 E$
- C. $2\pi R^2 E$
- D. $4\pi R^2 E$

7. A large, flat, horizontal sheet of charge has a charge per unit area of $\sigma = 25.0 \mu\text{C}/\text{m}^2$. What is the total charge of the 0.02 cm^2 sheet?

- A. $0.5 \mu\text{C}$
- B. $2.6 \mu\text{C}$
- C. 25 pC
- D. 50 pC

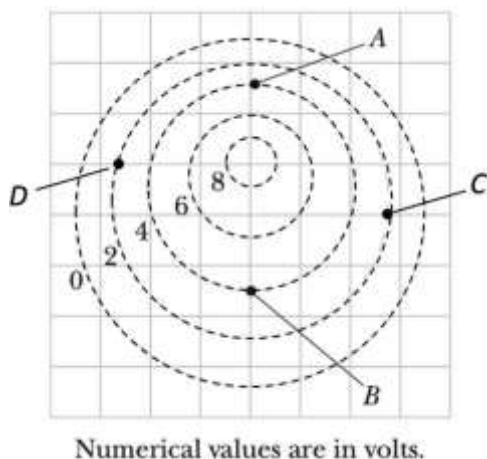
8. A long wire has a charge Q uniformly distributed throughout its length. A Gaussian surface of radius r and length l is used to calculate the magnitude of the electric field.



Which of the following equations results from the correct application of Gauss's law?

- A. $E(2\pi r l) = \frac{Q}{2\epsilon_0}$
- B. $E(2\pi r l) = \frac{Q}{\epsilon_0}$
- C. $E(\pi r^2 l) = 0$
- D. $E(\pi r^2 l) = \frac{Q}{\epsilon_0}$

9. The figure below shows equipotential surfaces in a region. An electron, initially at rest, moves from one point to another in the region.



In which of the following paths taken by the electron, is the work done by the electric field zero?

- A. From A to B
- B. From A to C
- C. From B to D
- D. From D to A

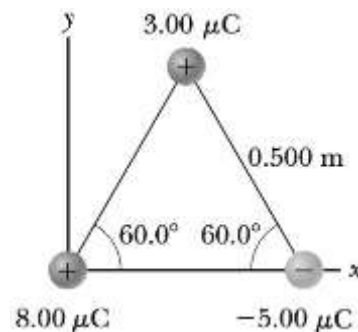
10. The electric potential V as a function of the position x along the $+x$ -axis is given by the equation:

$$V = 9x^2 + 4x + 5$$

What is the magnitude of the electric field at position $x = 2$?

- A. 40 V/m
- B. 42 V/m
- C. 44 V/m
- D. 49 V/m

11. The figure below shows three charges arranged at the corners of an equilateral triangle, with length of each side equal to 0.5 m .



What is the total potential energy stored in the configuration?

- A. -0.27 J
- B. -0.56 J
- C. -0.72 J
- D. $+0.43 \text{ J}$

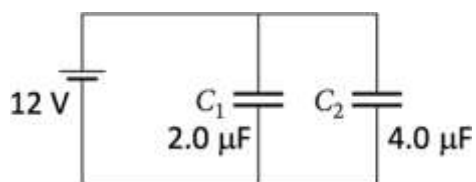
12. The potential difference across a capacitor is 25 V when it stores a charge of 100 μC . What is the capacitance of the capacitor?

- A. 0.25 μF
- B. 2.0 μF
- C. 4.0 μF
- D. 2500 μF

13. A parallel plate capacitor is fully charged using a battery. The battery is then removed and the plates of the capacitor are moved farther apart. What happens to the capacitance of the capacitor?

- A. Increases
- B. Decreases
- C. Stays the same
- D. Increases and then decreases

14. Two capacitor $C_1 = 2.0 \mu F$ and $C_2 = 4.0 \mu F$ are connected to a $12 V$ battery as shown below.



Which of the statements is true about the potential drop (V) and energy stored (U) in each capacitor?

	Potential Drop	Stored Energy
A.	$V_1 = V_2$	$U_1 < U_2$
B.	$V_1 = V_2$	$U_1 > U_2$
C.	$V_1 < V_2$	$U_1 < U_2$
D.	$V_1 < V_2$	$U_1 > U_2$

15. A parallel plate capacitor with a plate separation of 0.25 cm and cross-sectional area of 0.001 m^2 is filled with a material with dielectric constant of 3.0. What is the capacitance of the capacitor?

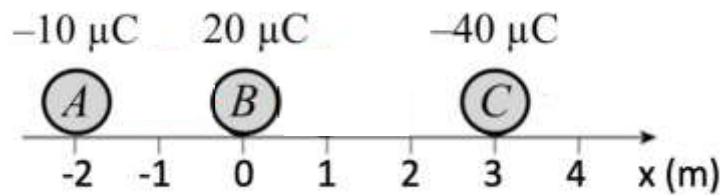
- A. $6.6 \mu F$
- B. $7.4 \mu F$
- C. 10.6 pF
- D. 11.8 pF

II. Answer the following questions.

[55 marks]

16. The figure below shows three point charges A, B and C located on an x-axis.

[8 marks]



a. On the figure above, draw the following:

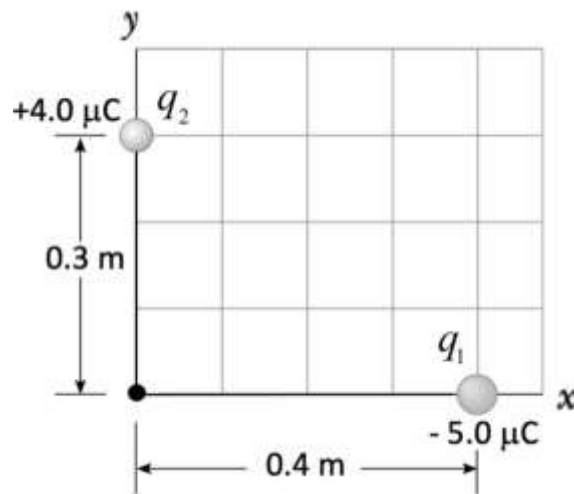
(2 marks)

- The force vector on charge B due to charge A. Label it as F_{AB} .
- The force vector on charge B due to charge C. Label it as F_{CB} .

b. Calculate the magnitude of the net electric force on charge $B = 20 \mu\text{C}$ at the origin.

(6 marks)

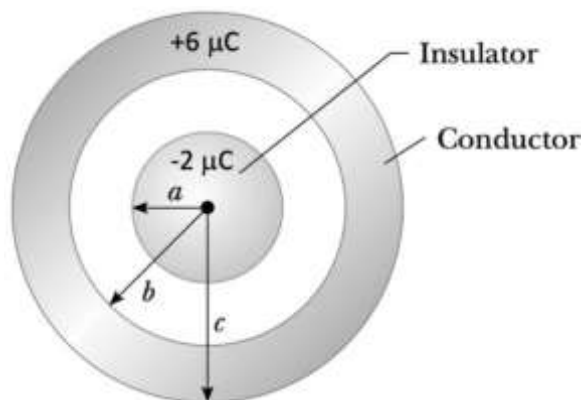
17. Two charges, $q_1 = -5.0 \mu\text{C}$ and $q_2 = +4.0 \mu\text{C}$ are located in the xy -plane as shown in the figure below. [10 marks]



- a. Calculate the **magnitude** of the net electric field at the origin. (7 marks)

- b. Find the **direction** of the net electric field at the origin. (3 marks)

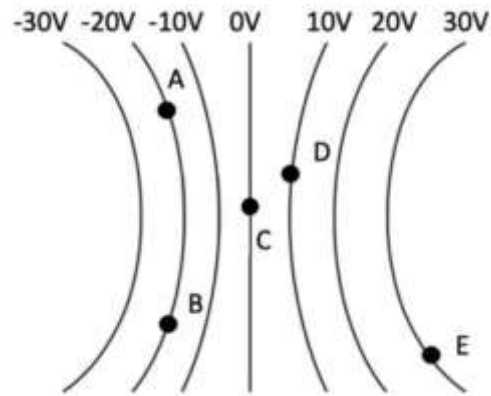
18. An insulating, solid sphere of radius $a = 0.02\text{ m}$ and carrying a charge of $-2\mu\text{C}$ is surrounded by a concentric spherical conducting shell of inner radius $b = 0.04\text{ m}$ and outer radius $c = 0.06\text{ m}$. The conducting shell has a net charge of $+6\mu\text{C}$. [12 marks]



- a. Determine the charge on the following surfaces:
- i. inner surface of the conducting shell. (1 mark)
 - ii. outer surface of the conducting shell. (1 mark)
- b. Calculate the electric field at a distance $r = 0.03\text{ m}$ from the center. (6 marks)
- c. Calculate the electric field at a distance $r = 0.07\text{ m}$ from the center (4 marks)

19. The diagram below shows equipotential lines in a particular region.

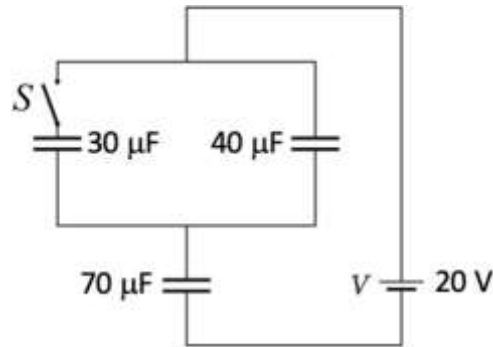
[13 marks]



- On the figure above, draw an arrow to indicate the direction of the electric field at point C .
(2 marks)
- At which point A, B, C, D or E is the magnitude of the electric field the least? Explain your answer.
(2 marks)
- Calculate the work done by the electric field in moving a $+5.0 \mu\text{C}$ charge from rest at point D to point B .
(4 marks)
- A proton, initially at rest, is accelerated from point E to D . What is its final velocity at D ?
(5 mark)

20. The circuit below shows three capacitors connected to a 20 V battery.

[12 marks]



a. Calculate the equivalent capacitance of the circuit, with the switch S open. (4 marks)

b. Calculate the equivalent capacitance of the circuit, when the switch S is closed. (4 marks)

c. Which of the following statements are true when a dielectric is inserted in an isolated charged parallel plate capacitor? Tick **TWO** boxes. (4 marks)

- ☐ the charge on one of the capacitor plates will decrease.
- ☐ the stored energy in the capacitor between the plates will decrease.
- ☐ the capacitance of the capacitor will increase.
- ☐ the voltage across the capacitor will increase.

End of Exam