

## Electromagnetism and Optics: Class Exam I

19 September 2018

Name: \_\_\_\_\_

Total: /70

### Instructions

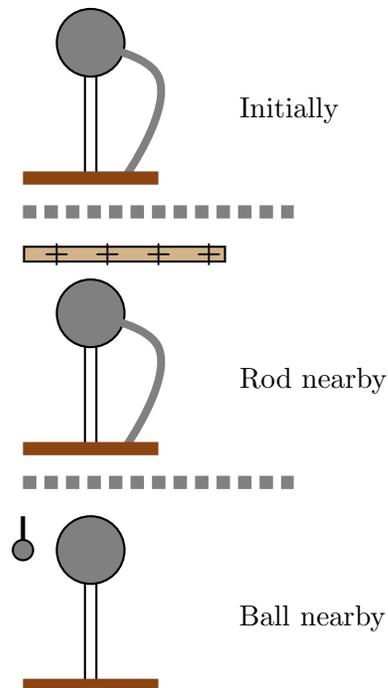
- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

### Physical constants and useful formulae

$$\begin{aligned}
 e &= 1.61 \times 10^{-19} \text{ C} & q_{\text{electron}} &= -e & q_{\text{proton}} &= +e \\
 m_{\text{electron}} &= 9.11 \times 10^{-31} \text{ kg} & m_{\text{proton}} &= 1.67 \times 10^{-27} \text{ kg} \\
 k &= 9.0 \times 10^{-9} \text{ Nm}^2/\text{C}^2 & \epsilon_0 &= 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2
 \end{aligned}$$

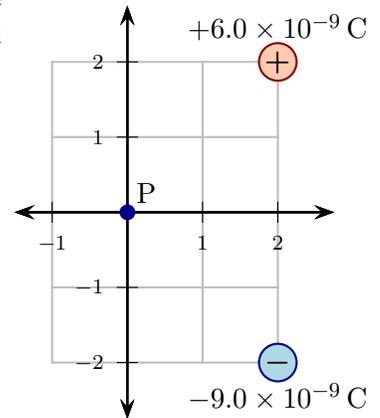
### Question 1

A metal ball on an insulating stand is initially neutral. The ball is connected to the earth by a wire. Then a positively charged rod is held above the ball but does not touch it. While the rod is in place, the wire is removed. After this the rod is removed. At this stage, a second metal ball suspended on a string and initially uncharged is brought into contact with the ball on the stand. Describe the charges on the two balls and whether they repel, attract or exert no force on each other. Explain your answer.



### Question 2

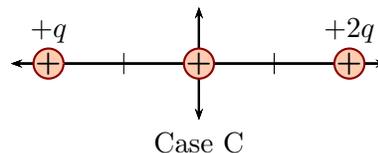
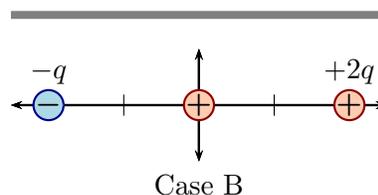
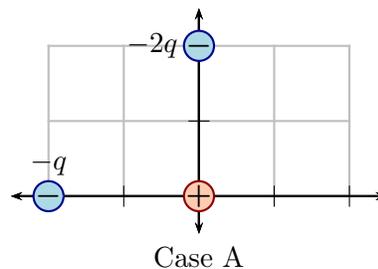
Two point charges are held fixed at the illustrated locations. The axis units are  $1.0 \times 10^{-3}$  m. Determine the **net** electric field produced by both of these at point P.



### Question 3

A  $+1.00\text{ C}$  particle is placed at the origin in the vicinity of other charge particles in various arrangements. Which of the following (choose one) is the correct rank of the *magnitudes* of the net force on the particle at the origin?

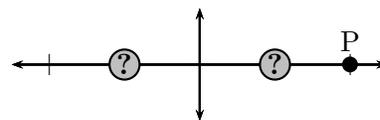
- i)  $F_{\text{case B}} < F_{\text{case A}} = F_{\text{case C}}$
- ii)  $F_{\text{case C}} < F_{\text{case A}} < F_{\text{case B}}$
- iii)  $F_{\text{case A}} < F_{\text{case C}} < F_{\text{case B}}$
- iv)  $F_{\text{case A}} < F_{\text{case B}} < F_{\text{case C}}$



/4

### Question 4

Two mystery point charges are held fixed at the indicated locations. An electron is placed at point P and the net force on the electron is right ( $+\hat{i}$ ). The electron is removed and replaced by a proton.



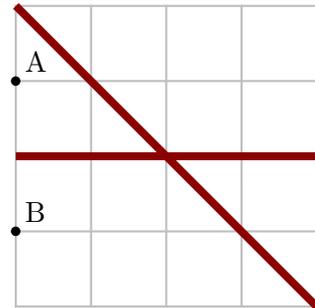
- a) Which of the following (choose one) is true regarding the electric field produced by the two mystery charges at the proton's location?
  - i)  $\vec{E} = 0$ .
  - ii)  $\vec{E} \neq 0$  and is  $\rightarrow$ .
  - iii)  $\vec{E} \neq 0$  and is  $\leftarrow$ .
- b) Which of the following (choose one) is true regarding the force exerted by the two mystery charges on the proton?
  - i)  $\vec{F} = 0$ .
  - ii)  $\vec{F} \neq 0$  and is  $\rightarrow$ .
  - iii)  $\vec{F} \neq 0$  and is  $\leftarrow$ .

/8

### Question 5

Two uniformly charged infinite planes intersect at an angle of  $45^\circ$ , as illustrated. Each carries charge with charge density  $+8.0 \times 10^{-6} \text{ C/m}^2$ . The grid units are  $0.010 \text{ m}$ .

- a) Determine the net electric field produced at point A.



- b) Two identical copies of this arrangement are created. In one a proton is placed at point A and, in the other, an electron is placed at point B. Which of the following (choose one) is true regarding the *magnitudes* of the net forces on the electron and proton?
- The magnitudes of the net forces are the same.
  - The magnitude of the net force on the electron is larger than that on the proton.
  - The magnitude of the net force on the electron is smaller than that on the proton.

/16

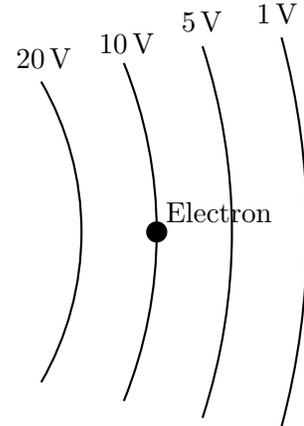
**Question 6**

A point particle with charge  $+2.0 \times 10^{-6} \text{ C}$  is held fixed. Another point particle with charge  $+4.0 \times 10^{-3} \text{ C}$  and mass  $0.080 \text{ kg}$  is fired directly toward the first from a distance of  $0.40 \text{ m}$  with a speed of  $90 \text{ m/s}$ . Determine the distance between the two charges when they are nearest to each other.

/10

**Question 7**

A charge distribution produces equipotentials as illustrated. An electron is placed at the illustrated location. Which of the following (choose one) best describes the direction of the force exerted on the electron?



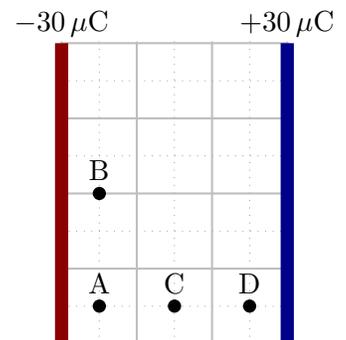
- i)  $\hat{i}$
- ii)  $-\hat{i}$
- iii)  $\hat{j}$
- iv)  $-\hat{j}$

**Briefly** explain your answer.

/8

**Question 8**

Two parallel plates carry equal but opposite charges as illustrated. The plates are large enough that they can be assumed to be infinite and the charge is uniformly distributed on each. Which of the following (choose one) best ranks the electric potentials at the illustrated points?



- i)  $V_A = V_B < V_C < V_D$
- ii)  $V_A < V_B < V_C < V_D$
- iii)  $V_D < V_C < V_B < V_A$
- iv)  $V_D < V_C < V_B = V_A$

/4