

## General Physics: Final Exam

13 May 2013

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

Total:

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### Instructions

- There are 16 questions on 11 pages.
- Show your reasoning and calculations and always justify your answers.

### Physical constants and useful formulae

Coulomb's constant:	$k = 9.0 \times 10^9 \text{ Nm}^2/\text{C}^2$
Electron charge:	$q_{\text{electron}} = -1.60 \times 10^{-19} \text{ C}$
Electron charge magnitude:	$e = 1.60 \times 10^{-19} \text{ C}$
Electron mass:	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Proton charge	$q_{\text{proton}} = +1.60 \times 10^{-19} \text{ C}$
Proton mass:	$m_p = 1.67 \times 10^{-27} \text{ kg}$
Neutron mass:	$m_n = 1.67 \times 10^{-27} \text{ kg}$
Permittivity of free space:	$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$
Permeability of free space:	$\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$
Speed of light:	$c = 3.00 \times 10^8 \text{ m/s}$
Planck's constant:	$h = 6.63 \times 10^{-34} \text{ Js} = 4.14 \times 10^{-15} \text{ eV s}$
eV conversion:	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$

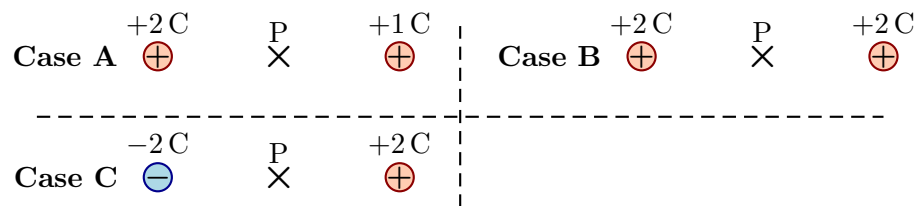
### Question 1

Two identical small conducting spheres on perfectly insulating stands are initially separated. Initially one holds a total charge  $4.0 \times 10^{-5} \text{ C}$ , the other is uncharged. The spheres are brought into contact and held this way until the charge redistributes itself into a settled state. They are then separated and held a distance of 0.50 m apart. Determine the charge on each individual sphere and the force, including direction, exerted by one sphere on the other at the end of this process.

### Question 2

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Three isolated pairs of charges are separated by the same distance.



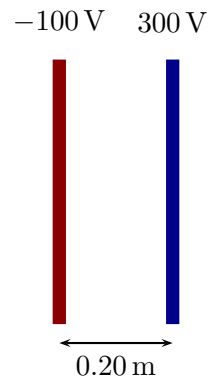
Which of the following (choose one) represents the rank of the **magnitude of the electric field at P**?

- a) Case B > Case A > Case C
- b) Case C > Case A > Case B
- c) Case B = Case C > Case A
- d) Case A > Case B > Case C

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### Question 3

Two large parallel plates are separated by 0.20 m and are charged giving rise to illustrated electric potentials. The electric field between the plates is uniform. An electron is initially held at rest on the left plate (that with potential  $-100\text{ V}$ ).

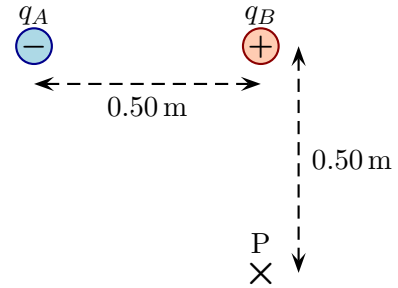


- a) The electron is released and eventually hits the plate on the right (that with potential  $300\text{ V}$ ). Determine the speed of the electron at the instant before it hits the plate on the right.
- b) Another charged particle, called Zog, is held at rest midway between the plates and released. Which of the following (choose one) is true regarding the direction of the electric field produced *by the plates* at the midpoint?
- i)  $\rightarrow$  if Zog is negative,  $\leftarrow$  if Zog is positive.
  - ii)  $\leftarrow$  if Zog is negative,  $\rightarrow$  if Zog is positive.
  - iii)  $\leftarrow$  regardless of Zog's charge.
  - iv)  $\rightarrow$  regardless of Zog's charge.
  - v) The electric field at the midpoint is zero.

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#### Question 4

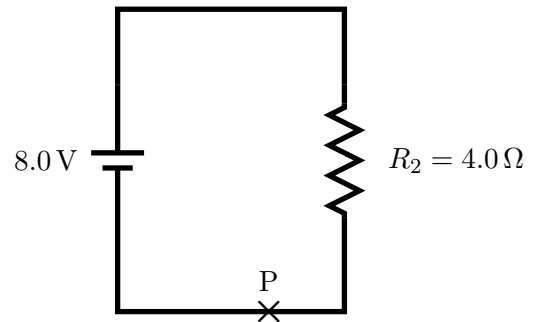
Two fixed charges are situated as illustrated. Their charges are  $q_A = -6.0 \times 10^{-9} \text{ C}$  and  $q_B = 3.0 \times 10^{-9} \text{ C}$ . Determine the magnitude of the force exerted on another particle with charge  $+0.25 \text{ C}$  placed at the point labeled P.



**Question 5**

A resistor is connected to a battery as illustrated.

- a) Determine the current that flows through the circuit and the time taken for a total charge of 10 C to pass point P as illustrated.



- b) Which of the following (choose one) is true regarding the total energy supplied by the battery to move a total charge  $Q$  through the resistor?
- i) The total energy is  $Q$ .
  - ii) The total energy equals the current flowing through the resistor.
  - iii) The total energy equals the voltage across the resistor.
  - iv) None of the above.

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**Question 6**

Two very long wires point directly out of the page and carry identical currents, pointing out of the page. Point X is midway between the wires and Y the same distance to the right of the rightmost wire. Which of the following (choose one) is true regarding the magnitudes of the net magnetic fields at points X and Y?

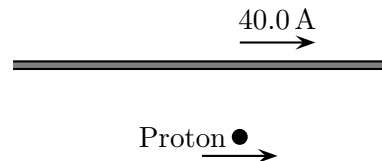


- a)  $B_X = B_Y = 0$     b)  $B_X = B_Y \neq 0$     c)  $B_X > B_Y$     d)  $B_X < B_Y$

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**Question 7**

An infinitely long wire carries current a current of 40 A. At the instant illustrated below, a proton is at a distance of  $1.0 \times 10^{-2}$  m from the wire and travels with speed  $4.0 \times 10^5$  m/s parallel to the wire.

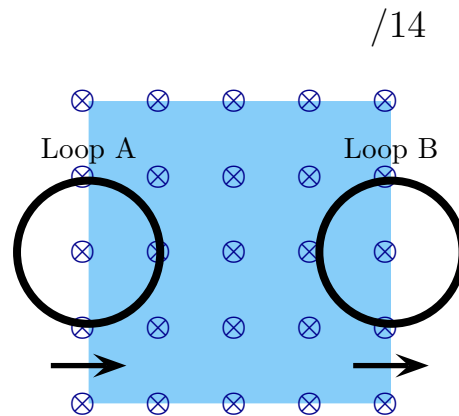


- a) Determine the magnetic field (magnitude and direction) produced by the current at the location of the proton.
  
- b) Determine the force (magnitude and direction) exerted by the current on the proton.

**Question 8**

There is a uniform constant magnetic field throughout the shaded region. Two loops identical loops are dragged at the same rate to the right. Which of the following (choose one) is true regarding the currents in the loops at the indicated moment?

- a)  $I_A = I_B = 0$ .
- b)  $I_A$  is clockwise,  $I_B$  is clockwise.
- c)  $I_A$  is clockwise,  $I_B$  is counterclockwise.
- d)  $I_A$  is counterclockwise,  $I_B$  is clockwise.
- e)  $I_A$  is counterclockwise,  $I_B$  is counterclockwise.



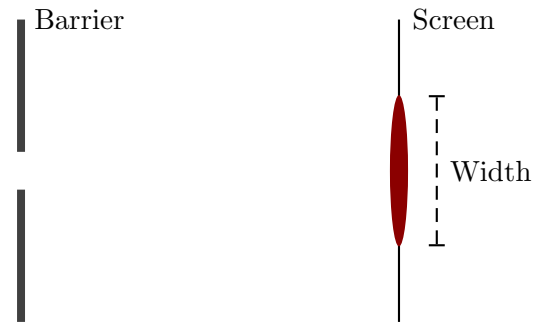
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### Question 9

A light source illuminates a single slit and produces the illustrated central bright fringe on a screen. This light source is replaced by one with a larger wavelength. Which of the following (choose one) is true regarding the central bright fringe?

- a) Width stays same.
- b) Width increases.
- c) Width decreases.

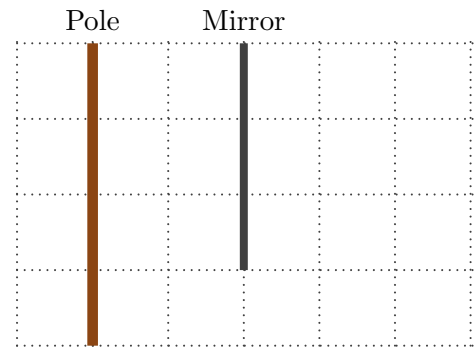


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### Question 10

A pole of height 4 m is placed to 2 m to the right of a mirror. The height of the mirror is 3 m and the top of the mirror is level with the pole.

- a) Draw the image of the pole produced by the mirror as accurately as possible on the diagram. Determine the height of the image.



- b) An ant at the base of the pole looks into the mirror. What length of the image is the ant able to see? Explain your answer.

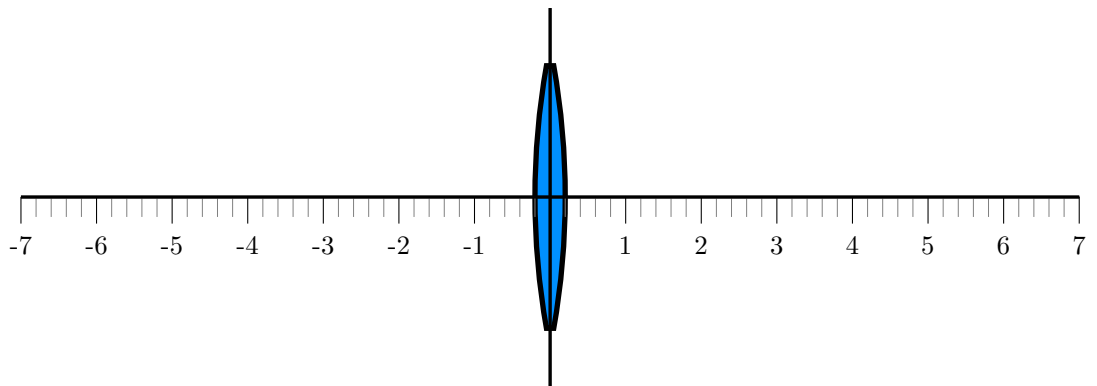
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### Question 11

An object of height 1.0 cm is placed 3.0 cm to the left of a convex lens whose focal length is 2.0 cm.

a) Determine the location of the image produced by the lens *using equations*.

b) Sketch the situation, indicating the object and the image, as accurately as possible using the diagram below.



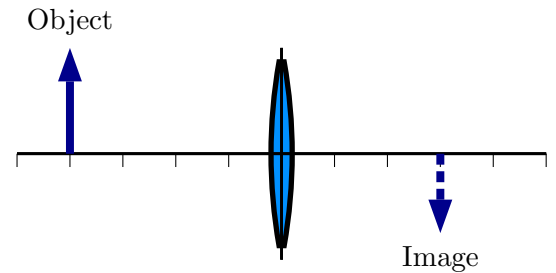
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### Question 12

A thin convex lens is used to produce a real image of an object as illustrated. Which of the following (choose one) is true?

- a) The focal point of the lens is at the location of the image.
- b) The focal point of the lens is between the image and the lens.
- c) The focal point is right of the image.



Explain your answer (diagrams can be a legitimate part of the explanation).

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### Question 13

Many boxes each have length  $4.0 \times 10^{-10}$  m. One electron is placed in each box. Which of the following is true regarding the light emitted by these electrons?

- a) The emission spectrum consists of exactly one wavelength.
- b) The emission spectrum consists of many wavelengths and these have discrete values.
- c) The emission spectrum consists of many wavelengths and these have a continuous range of values.

Explain your answer.

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**Question 14**

A quantum system has the three illustrated energy levels. Determine *all* the wavelengths of the electromagnetic radiation in the system's emission spectrum.

7.0 eV —————

3.0 eV —————

1.0 eV —————

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**Question 15**

A sodium lamp produces light with wavelength  $589 \times 10^{-9}$  m and has power 2.0 W. A laser also has power 2.0 W and produces light with wavelength  $650 \times 10^{-9}$  m. Which of the following (choose one) is true?

- a) Each produces the same number of photons per second.
- b) The sodium lamp produces more photons per second.
- c) The mercury lamp produces more photons per second.

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