Instructor(s): *Profs. Korytov, Takano*

PHYSICS DEPARTMENT

PHY 2049, Fall 2016 FINAL EXAM December 14, 2016

Name (print): _____ Signature: _____

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

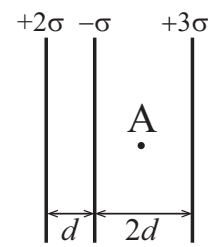
(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work.
(4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know.
(5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.
(6) **Blacken the circle of your intended answer completely, using a number 2 pencil**. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.
(7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, NOT what you circle here. Good luck!!!

>>>>>>>>**WHEN YOU FINISH** <<<<<<<<

Hand in the answer sheet separately.

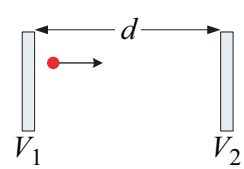
Constants			
$e = 1.6 \times 10^{-19}$ C	$m_p = 1.67 \times 10^{-27}$ kg	$m_e = 9.1 \times 10^{-31}$ kg	$\epsilon_o = 8.85 \times 10^{-12}$ C^2/N·m^2
milli (m) $= 10^{-3}$	micro (μ) $= 10^{-6}$	nano (n) $= 10^{-9}$	pico (p) $= 10^{-12}$
$k = 1/(4\pi\epsilon_o) = 9 \times 10^9$ N·m^2/C^2		$\mu_0 = 4\pi \times 10^{-7}$ T·m/A	
Sphere: $A = 4\pi R^2$ $V = \frac{4\pi}{3}R^3$			

1. Three large thin parallel plates made of insulating material are separated by distances d and $2d$. They carry charges, whose surface densities are $+2\sigma$, $-\sigma$, and $+3\sigma$, as shown in the figure. What is the magnitude of the electric field at point A in the middle between the second and third plates? (*Hint: Electric fields are vectors that add as such.*)



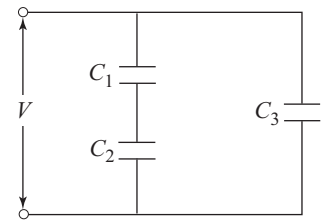
(1) $\frac{\sigma}{\epsilon_0}$ (2) $\frac{2\sigma}{\epsilon_0}$ (3) $\frac{\sigma}{2\epsilon_0}$ (4) $\frac{3\sigma}{2\epsilon_0}$ (5) $\frac{3\sigma}{\epsilon_0}$

2. An electron is moving rightward between two parallel charged plates separated by distance $d = 1.0$ cm, as shown in the figure. The plate potentials are $V_1 = -20$ V and $V_2 = -30$ V. If the initial speed of the electron at the left plate is 1.0 km/s, what is its speed just as it reaches the right plate?



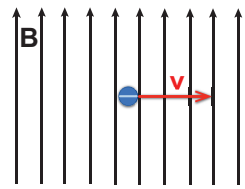
(1) The electron will never reach the right plate. (2) 1,900 km/s (3) 230 km/s (4) 64 km/s (5) 7.6 km/s

3. In the figure, a potential difference of $V = 24$ V is applied across the arrangement of capacitors with capacitances $C_1 = 1\,\mu$F, $C_2 = 2\,\mu$F and $C_3 = 3\,\mu$F. What is the charge on one of the plates of capacitor C_1?



(1) 16 μC
(2) 12 μC
(3) 8 μC
(4) 6 μC
(5) 4 μC

4. An electron (negative charge!) moves to the right in magnetic field B pointing up, as shown in the figure. What is the direction of the force experienced by the electron?



(1) into the page (2) down (3) up (4) out of page (5) force is zero

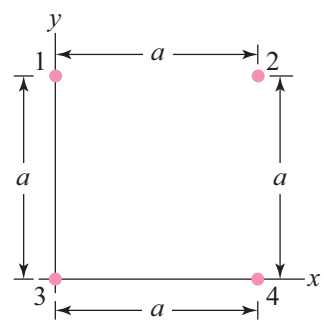
5. An LC circuit has a capacitance of $100\,\mu$F and an inductance of 10 mH. At time $t = 0$ the charge on the capacitor is $2\,\mu$C and the current in the circuit is 1 mA. What is the maximal current in the circuit at a later time, in mA?

(1) 2.2 (2) 1.1 (3) 1.6 (4) 3.2 (5) 4.5

6. An RLC circuit ($R = 100\,\Omega$, $L = 200$ mH, $C = 10\ \mu$F) is connected to alternating emf $\mathcal{E}(t) = \mathcal{E}_m \sin(\omega_d t)$, where $\mathcal{E}_m = 300$ V and $\omega_d = 1000$ s^{-1}. What is the amplitude of the oscillating current in the circuit?

(1) 2.1 A (2) 6.0 A (3) 3.3 A (4) 4.2 A (5) 1.4 A

7. In the figure, the particles have charges $q_1 = 6\,\mu$C, $q_2 = -16\,\mu$C, $q_3 = 4\,\mu$C and $q_4 = 6\,\mu$C, and distance $a = 5.0$ cm. What is the magnitude of the net electrostatic force on particle 3?

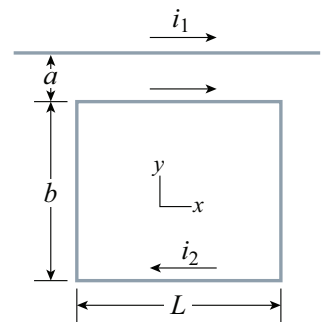


(1) 7 N
(2) 3 N
(3) 18 N
(4) 108 N
(5) 250 N

8. A proton is located at $x = 1$ m in an electric potential of the form $V(x) = x + 2x^2$, where x is measured in meters and $V(x)$ is measured in volts. What is the magnitude of the force acting on the proton, in newtons?

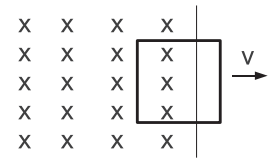
(1) 8.0×10^{-19} N (2) 1.6×10^{-19} N (3) 3.2×10^{-19} N (4) 4.8×10^{-19} N (5) 5.6×10^{-19} N

9. In the figure, a long straight wire carries a current $i_1 = 30.9$ A and a rectangular loop carries current $i_2 = 17.4$ A. Take $a = 1.44$ cm, $b = 6.39$ cm, and $L = 33.8$ cm. What is the magnitude of the net force on the loop due to i_1?



(1) 2.06×10^{-3} N
(2) 1.96×10^{-3} N
(3) 2.99×10^{-3} N
(4) 3.09×10^{-3} N
(5) 3.31×10^{-3} N

10. A square loop of side 2 cm moves with velocity 3 m/s at $t = 0$ as it exits a region of uniform magnetic field 5 T into the page (see figure). If the loop has resistance 0.4 Ω, what is the magnitude of the magnetic force on it at $t = 0$?



(1) 7.5×10^{-2} N (2) 7.5×10^{-1} N (3) 3.0×10^{-3} N (4) 3.7×10^{1} N (5) 4.2 N

11. Consider a circular parallel-plate capacitor that is being charged. Which of the following statements about the *magnetic* field *between* the plates is correct? (r refers to the distance from the capacitor centerline, *i.e.,* the line connecting the centers of the two plates.)

(1) field lines are circular; field strength is proportional to r
(2) field lines are circular; field strength is proportional to $1/r$
(3) field lines are radial; field strength is proportional to r
(4) field lines are radial; field strength is proportional to $1/r$
(5) field is zero everywhere between the plates

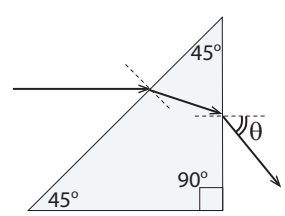
12. If the magnetic field in a plane electromagnetic wave is along the y axis and its component is given by $B_m \sin(kx - \omega t)$ in SI units, then the electric field is along the z axis, and its component is given by:

(1) $-(cB_m)\sin(kx - \omega t)$
(2) $-(cB_m)\cos(kx - \omega t)$
(3) $(cB_m))\sin(kx - \omega t)$
(4) $B_m \sin(kx - \omega t)$
(5) $(cB_m)\cos(kx - \omega t)$

13. A sinusoidal electromagnetic wave with an electric field amplitude of 100 V/m is incident normally on a surface with an area of 1 cm^2 and is completely absorbed. The energy absorbed in 10 s is:

(1) 13 mJ (2) 1.3 mJ (3) 27 mJ (4) 130 mJ (5) 270 mJ

14. A ray of light traveling horizontally enters a prism as shown in the figure. The index of refraction of the prism is $n = 1.6$, and the prism is surrounded by air. What is the value of the angle θ between the horizontal and the direction of the ray leaving the prism?



(1) 31° (2) 26° (3) 19° (4) 45° (5) 64°

15. An unpolarized beam of light has intensity I_0. It is incident on two ideal polarizing sheets. The angle between the axes of polarization of these sheets is θ. Find θ if the emerging light has intensity $I_0/4$:

(1) 45° (2) 30° (3) 60° (4) 15° (5) 75°

16. Suppose an object on the central axis of a spherical mirror is magnified by $m = +4$. Is the image on the same side (S) or opposite (O), is it real (R) or virtual (V), and is it inverted (I) or not inverted (NI)?

(1) O, V, NI (2) S, V, I (3) S, R, I (4) O, R, NI (5) S, R, NI

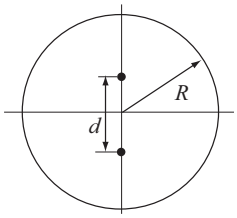
17. A professor of physics cannot see clearly at a distance shorter than 1 m. What should be the focal length of an eyeglass lens that would assist him in reading a newspaper while holding it at a desired distance of 25 cm? *Hint: the lens should form an image of the newspaper at a distance where the professor can see it.*

(1) 33 cm (2) 50 cm (3) 75 cm (4) 100 cm (5) 125 cm

18. Light of wavelength 600 nm is projected through two very narrow slits, spaced 2 mm apart, onto a screen placed 5 m away from the slits. What is the distance between adjacent bright fringes in the interference pattern formed on the screen?

(1) 1.5 mm (2) 4.8 mm (3) 2.4 mm (4) 3.0 mm (5) 6.0 mm

19. Two coherent radio-frequency point sources separated by $d = 3$ m radiate in phase at a wavelength $\lambda = 1$ m. A radio wave detector moves in a circular path of some radius R around the mid-point between the two sources (see figure) and measures the radio-wave intensity of the signal. Find how many maxima it detects. *Hint: consider the phase difference for wave emitted by the two sources at the bottommost point of the circle and then at the topmost point. Contemplate what happens to the phase difference as one moves along the circle from the bottommost to the topmost point.*



(1) 12 (2) 36 (3) 24 (4) 18 (5) 6

20. The Thirty Meter Telescope will be commissioned in year 2022. Its reflective mirror will be 30 m in diameter, as the telescope name suggests. In December 2022, Mars will be at its closest approach to Earth of about 80,000,000 km (such close approaches happen approximately once in three years). Approximately, what is the smallest size of an object that this telescope will be able to resolve on Mars at that time? The wavelength of visible light ranges from 400 to 600 nm.

(1) 2 km (2) 200 m (3) 20 m (4) 2 cm (5) 20 cm