

Time: 120 min

PRACTICE FINAL EXAM  
PS 250

TOTAL POINTS: 100

- NOTES:**
1. Do not tear off this page from the rest of the exam.
  2. This exam consists of 28 multiple choice problems.
  3. You will be graded on your best 25 problems.
  4. All problems carry equal credit (4 points each).
  5. You will not be given any partial credit on any problem.
  6. You do not need to show work.
  7. Programmable calculators are not allowed.
  8. Index card is allowed, but scratch paper is not allowed
  9. Best of luck!!!

**CONSTANTS:**

Coulomb's constant:	$k = 1/(4\pi \epsilon_0) = 8.99 \cdot 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
Permeability:	$\mu_0 = 4 \pi \times 10^{-7} \text{ T}\cdot\text{m}/\text{A}$
Elementary charge:	$e = 1.6 \cdot 10^{-19} \text{ C}$
Mass of an electron:	$m_e = 9.1 \cdot 10^{-31} \text{ kg}$
Mass of a proton:	$m_p = 1.67 \cdot 10^{-27} \text{ kg}$
Planck's constant:	$h = 6.63 \cdot 10^{-34} \text{ Js}$
Rydberg's constant:	$R = 1.097 \times 10^7/\text{m}$
Gravitational acceleration at Earth's surface:	$g = 9.8 \text{ m}/\text{s}^2$
The speed of light:	$c = 3.00 \cdot 10^8 \text{ m}/\text{s}$
1 eV	$1.6 \cdot 10^{-19} \text{ J}$
Gravitational constant:	$G = 6.67 \times 10^{-11} \text{ nm}^2/\text{kg}^2$

1. A non-conducting sphere with radius 1 m carries a charge of 16 nC distributed uniformly throughout. Find the electric field for  $r = 0.5$  m. Assume the dielectric constant of the region is not significantly different from  $\epsilon_0$ .

- a. 18 N/C
- b. 36 N/C
- c. 72 N/C \*
- d. 144 N/C
- e. 256 N/C

2. Find the magnitude of the electric field at (2, 3) due to a charge of 3.0 nC at (2,-2) and a charge of -5.0 nC at (-2,0), where (x,y) denote x and y coordinates in meters.

- a. 1.4 N/C \*
- b. 1.0 N/C
- c. 2.1 N/C
- d. 1.8 N/C
- e. 2.8 N/C

3. An electron and a proton are separated by  $5.31 \times 10^{-11}$  m. What is the ratio of the electric force to the gravitational force between them?

- a.  $3.930 \times 10^4$
- b.  $6.238 \times 10^{23}$
- c.  $2.27 \times 10^{39}$  \*
- d.  $1.982 \times 10^{17}$
- e.  $8.145 \times 10^{31}$

4. An electron is released from rest at the negative plate of a parallel-plate capacitor. If the distance across the plate is 5.0 mm and the potential difference across the plate is 5.0 V, with what velocity does the electron hit the positive plate?

- a.  $2.6 \times 10^5$  m/s
- b.  $5.3 \times 10^6$  m/s
- c.  $1.0 \times 10^6$  m/s
- d.  $1.3 \times 10^6$  m/s \*
- e.  $0.9 \times 10^6$  m/s

5. Over a certain region of space, the electric potential is  $V = 5x - 3x^2y + 2yz^2$ . Calculate the y component of the electric field (in V/m) at  $\mathbf{r}=(1,0,-2)$ .

- a. -5 \*
- b. 5
- c. 0
- d. 7
- e. -7

6. The spacecraft Deep Space 1 uses a plasma engine for propulsion in which it accelerates Xenon ions to an exhaust velocity of 30 km/s. (The mass of one Xenon ion is 131.29 amu; and 1 amu =  $1.66 \times 10^{-27}$  kg. The Xenon is singly-ionized, which means it has a charge  $+e$ .) If the ions are initially at rest, through what potential difference must they be accelerated to reach the required velocity?

- a. 613 V \*
- b. 131 V
- c. 9.2 V
- d.  $1.66 \times 10^{-27}$  V
- e.  $1.6 \times 10^{-19}$  V

7. What happens to the net electric flux through the surface of a sphere when the charge inside the sphere is doubled?

- a. it remains the same
- b. it is doubled \*
- c. it increases by a factor of 4
- d. it decreases by a factor of 2
- e. it decreases by a factor of 4

8. Three capacitors of 1.0, 1.5, and 2.0  $\mu\text{F}$  are connected in series. Find the equivalent capacitance.

- a. 4.5  $\mu\text{F}$
- b. 4.0  $\mu\text{F}$
- c. 2.2  $\mu\text{F}$
- d. 0.46  $\mu\text{F}$  \*
- e. 9.2  $\mu\text{F}$

9. A 10.0- $\mu\text{F}$  capacitor is charged by a 10.0-V battery through a resistance  $R$ . The capacitor reaches a potential difference of 4.00 V at the instant 3.00 s after charging begins. Calculate value of  $R$  in *kilo Ohms*.

- a. 587 \*
- b. 133
- c. 675
- d. 247
- e. 467

10. If a metallic wire of cross sectional area  $3.0 \times 10^{-6}$  m<sup>2</sup> carries a current of 6.0 A and has a mobile charge density of  $4.24 \times 10^{28}$  carriers/m<sup>3</sup>, what is the average drift velocity of the mobile charge carriers? (charge value =  $1.6 \times 10^{-19}$  C)

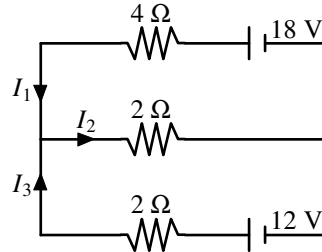
- a.  $3.4 \times 10^3$  m/s
- b.  $1.7 \times 10^3$  m/s
- c.  $1.5 \times 10^{-4}$  m/s
- d.  $2.9 \times 10^{-4}$  m/s \*
- e.  $4.5 \times 10^{-4}$  m/s

11. A copper cable needs to carry a current of 200 A with a power loss of only 3.0 W/m. What is the required radius of the copper cable? (The resistivity of copper is  $1.7 \times 10^{-8} \Omega \cdot \text{m}$ .)

- a. 0.21 cm
- b. 0.85 cm \*
- c. 3.2 cm
- d. 4.0 cm
- e. 2.0 cm

12. Calculate the magnitude of  $I_3$ .

- a. 1.2 A
- b. 1.8 A \*
- c. 2.4 A
- d. 4.2 A
- e. 4.8 A



13. A battery with an emf of 18 volts has a terminal voltage of 16 V when delivering 32 W of power to an external resistor  $R$ . What is the internal resistance  $r$  of the battery?

- a. 0.50  $\Omega$
- b. 1.0  $\Omega$  \*
- c. 2.0  $\Omega$
- d. 4.0  $\Omega$
- e. 8.0  $\Omega$

14. A circular loop carrying a current of 1.0 A is oriented in a magnetic field of 0.35 T. The loop has an area of  $0.24 \text{ m}^2$ . If the plane of the loop is oriented parallel to the field, what torque is created by the interaction of the loop current and the field?

- a. 5.8 N·m
- b. 0.68 N·m
- c. 0.084 N·m \*
- d. 0.017 N·m
- e. 0.34 N·m

15. Which one of the following statements concerning a current loop in a uniform magnetic field is FALSE?

- a. Such a device is the principle behind the electric motor.
- b. The torque on the loop is zero when the vector normal to the plane of the loop is oriented perpendicular to the magnetic field direction. \*
- c. The energy of the system is a minimum when the vector normal to the plane of the loop is in the direction of the magnetic field.
- d. The net force on the loop is always zero.
- e. The magnetic field produced by a circular current loop is dipole in nature.

16. Two long parallel wires each carry a current of 5.0 A. These two currents are oppositely directed. The two wires are separated by 6.0 cm. What is the magnitude in  $\mu\text{T}$  of the magnetic field at a point that is 5.0 cm from each of the wires?

- a. 20
- b. 32
- c. 40
- d. 24 \*
- e. 16

17. A long straight cylindrical wire of 0.50 cm radius carrying a 2.0 A current is surrounded by a concentric cylindrical shell of 0.50-cm thickness and inner radius 1.00 cm carrying a 2.0 A current in the opposite direction. The magnitude of the magnetic field, in  $\mu\text{T}$ , 0.40 m from the center of the cylindrical wire is

- a. 0. \*
- b. 1.0.
- c. 2.0.
- d.  $2\pi$ .
- e.  $4\pi$ .

18. A large jetliner with a wingspan of 40 m flies horizontally and due north at a speed of 300 m/s in a region where the magnetic field of the earth is  $60 \mu\text{T}$ . Jetliner's velocity vector and the Earth's magnetic field are in  $50^\circ$  angle. What is the magnitude of the induced *emf* between the ends of the wing?

- a. 250 mV
- b. 350 mV
- c. 550 mV \*
- d. 750 mV
- e. 660 mV

19. The magnetic field perpendicular to a certain circular region of radius 2.0 m increases with time according to the equation  $B = t^2$  (all in SI units). After 5.0 s, what is the magnitude of the induced electric field 3.0 m from the center?

- a. 6.7 N/C \*
- b. 12 N/C
- c. 4.5 N/C
- d. 21 N/C
- e. 13.4 N/C

20. An electric field of  $4.0 \mu\text{V}/\text{m}$  is induced at a point 2.0 cm from the axis of a long solenoid (radius = 3.0 cm, 800 turns/m). At what rate in A/s is the current in the solenoid changing at this instant?

- a. 0.50
- b. 0.40 \*
- c. 0.60
- d. 0.70
- e. 0.27

21. What is the maximum value of the electric field  $E$  of the electromagnetic wave at 1.0 m from a 100-W light bulb radiating in all directions? ( $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$ ,  $c = 3.00 \times 10^8 \text{ m/s}$ )

- a. 77 V/m \*
- b. 2 000 V/m
- c. 4 000 V/m
- d. 6 000 V/m
- e. 120 V/m

22. An AM radio station broadcasts equally in all directions with an average power of 4.00 kW. A dipole receiving antenna 65.0 cm long is at a location 4 km from the transmitter. Compute the amplitude of the *emf* induced by this signal between the ends of the receiving antenna.

- a. 49.5 mV
- b. 79.6 mV \*
- c. 101 mV
- d. 218 mV
- e. 370 mV

23. In an electromagnetic wave,  $\vec{E}$  and  $\vec{B}$  are

- a. perpendicular to one another.
- b. perpendicular to the direction of wave propagation.
- c. parallel to the direction of wave propagation.
- d. described by both (a) and (b). \*
- e. described by both (a) and (c).

24. What minimum strength magnetic field is required to turn a proton through a circular arc of radius 20 cm if it is traveling at a speed of 0.1  $c$ ? (Neglect relativistic effects.)

- a. 0.5 T
- b. 0.7 T
- c. 1.2 T
- d. 0.2 T
- e. 1.6 T \*

25. An  $RL$  series circuit has a battery of 40 V, a resistor of 20  $\Omega$ , and an inductor of 2 H all in series. What is the current 10 s after the circuit is completed?

- a. 1 A
- b. 2 A \*
- c. 4 A
- d. 8 A
- e. 16 A

26. If a monochromatic light beam with quantum energy value of 3.0 eV incident upon a photocell where the work function of the target metal is 1.60 eV, what is the maximum kinetic energy of ejected electrons?

- a. 4.6 eV
- b. 4.8 eV
- c. 1.4 eV \*
- d. 2.4 eV
- e. 0 eV

27. An electron microscope operates with electrons of kinetic energy 50.0 keV. What is the wavelength of these electrons? Assume this speed is not relativistic.

- a.  $9.28 \times 10^{-10}$  m
- b.  $7.14 \times 10^{-11}$  m
- c.  $5.49 \times 10^{-12}$  m \*
- d.  $2.75 \times 10^{-13}$  m
- e.  $4.65 \times 10^{-11}$  m

28. At what fraction of  $c$  (speed of light) must a meter stick be moving to appear to be 75 cm in length to a stationary observer?

- a. 0.57
- b. 0.59
- c. 0.63
- d. 0.65
- e. 0.66 \*