Physics 272– Practice Final Exam
Spring 2012
Prof. Mohan Kalelkar

Your name sticker with exam code

1. The exam will last from 1:30pm to 3:00pm. Use a #2 pencil to make entries on the answer sheet. Enter the following id information now, before the exam starts.

2. In the section labelled NAME, enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.

3. Under STUDENT # enter your 9-digit Student ID Number. Under COURSE enter 272. Under CODE enter the exam code given above.

4. During the exam, you may use pencils, a calculator, and ONE $8\frac{1}{2}'' \times 11''$ sheet of paper with formulas and notes.

5. There are 24 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no subtraction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in only the answer sheet. Retain this question paper for future reference and study.

6. Useful numerical constants are given on the next page. Before starting the exam, make sure that your copy contains the page of constants and all 24 questions. Bring your exam to the proctor if this is not the case.
Acceleration due to gravity \( g = 9.8 \, \text{m/s}^2 \)
Elementary charge \( e = 1.6 \times 10^{-19} \, \text{C} \)
Proton charge = \( 1.6 \times 10^{-19} \, \text{C} \)
Electron charge = \( -1.6 \times 10^{-19} \, \text{C} \)
1 electron volt (eV) = \( 1.6 \times 10^{-19} \, \text{J} \)
Proton mass = \( 1.673 \times 10^{-27} \, \text{kg} = 938.3 \, \text{MeV}/c^2 \)
Electron mass = \( 9.11 \times 10^{-31} \, \text{kg} = 0.511 \, \text{MeV}/c^2 \)
\( 1/4\pi \varepsilon_0 = 9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2 \)
\( \mu_0 = 4\pi \times 10^{-7} \, \text{T} \cdot \text{m/A} \)
Index of refraction of air = 1.00

Powers of ten:

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<th>femto(f)</th>
<th>pico(p)</th>
<th>nano(n)</th>
<th>micro(µ)</th>
<th>milli(m)</th>
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<td>(10^{-15})</td>
<td>(10^{-12})</td>
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<td>centi(c)</td>
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<td>(10^{-2})</td>
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1. A proton (charge = +e; mass = $M$) and a deuteron (charge = +e; mass = $2M$) enter the same magnetic field, and both move in circular paths. The radius of the proton's path is twice that of the deuteron's. It follows that the proton's kinetic energy is
   a) twice that of the deuteron's
   b) half that of the deuteron's
   c) eight times that of the deuteron's
   d) four times that of the deuteron's
   e) one-quarter of the deuteron's

2. See the figure for this question. At $x = 0$ a long straight wire carries current $I$ INTO the plane of the paper. At $x = D$, another long straight wire carries current $2I$ INTO the plane of the paper. What is the direction of the force on the wire at the origin?
   a) Towards the positive x-direction
   b) Towards the positive y-direction
   c) Out of the plane of the paper
   d) Towards the negative x-direction
   e) None of the other answers

3. In the preceding problem, at what point on the x-axis is the net magnetic field due to the two wires equal to zero? (Exclude points at infinity from consideration).
   a) $x = D$
   b) $x = D/2$
   c) $x = D/3$
   d) $x = -D$
   e) $x = -2D$

4. See the figure for this question. A segment of a wire is in the shape of an arc of a circle of radius $R$, and carries current $I$ in the direction shown. The arc subtends a 45° angle. What is the contribution to the magnetic field at the center $C$ by the current in the arc?
   a) $\mu_0 I/4R$ out of the paper
   b) $\mu_0 I/4R$ into the paper
   c) $\mu_0 I/2R$ into the paper
   d) $\mu_0 I/16R$ into the paper
   e) $\mu_0 I/16R$ out of the paper
5. See the figure for this question. A rectangular loop of wire of dimensions $a$ and $b$ is being pulled with speed $v$ out of a uniform magnetic field $B$ directed into the paper. If the loop has a resistance $R$, what is the induced current in it, when it is partially out of the field as shown in the figure?

a) $Bav/R$ clockwise
b) $Bbv/R$ clockwise
c) Zero
d) $Bav/R$ counterclockwise
e) $Bbv/R$ counterclockwise

6. See the figure for this question. Two concentric circular loops of wire lie in the plane of the paper. The outer loop carries a current $I$. Which of the following is true?

- I: If $I$ is counterclockwise and constant, the induced current in the inner loop will be nonzero and clockwise.
- II: If $I$ is counterclockwise and increasing, the induced current in the inner loop will be nonzero and counterclockwise.
- III: If $I$ is clockwise and decreasing, the induced current in the inner loop will be nonzero and clockwise.

a) I and II are true; III is false
b) II and III are true; I is false
c) I and III are true; II is false
d) Only III is true
e) Only I is true

7. If the current through an inductor is INCREASING, which of the following statements will be true?

a) The self-induced emf is zero
b) The energy in the inductor remains constant
c) The inductance of the inductor is decreasing
d) The inductance of the inductor is increasing
e) None of the other statements are true
8. An ideal transformer has 200 primary turns and 50 secondary turns. If 400 volts (rms) is placed across the primary, what is the current (rms) in the secondary if the total resistance in the secondary circuit is 5 \( \Omega \)?
   a) None of the other answers
   b) 80 A
   c) 20 A
   d) Zero
   e) 320 A

9. Which of the following statements are true?
   - I: Electric utilities use a transformer to step up the voltage before transmission, so as to reduce power losses during transmission.
   - II: Transformers work equally well with DC input as with AC.
   - III: A step-up transformer increases both the voltage and the current.
   a) I and II are true; III is not
   b) Only I is true
   c) I and III are true; II is not
   d) Only II is true
   e) None of the statements are true

10. An electromagnetic wave is traveling along the \( +j \) direction. Its associated magnetic field is along the \( -i \) direction at one instant. What is the direction of the associated electric field at that instant?
    a) \( +i \)
    b) \( -j \)
    c) \( +k \)
    d) \( -i \)
    e) None of the other answers

11. An astronaut of the future steps out of her spaceship into interstellar space. She fires a laser that provides \( 10^9 \text{ W} \) of power continuously for one minute. If the total mass of the astronaut and her equipment is 100 kg, how far does she move in that minute, assuming she started from rest?
    a) More than 100 m
    b) Less than 4 m
    c) Between 40 and 100 m
    d) Between 4 and 10 m
    e) Between 10 and 40 m
12. A 100 W light bulb is radiating light in all directions. A panel of area 0.01 m$^2$ is located 5 m from the bulb, and the light hits it perpendicularly. What is the radiation force on the panel, assuming that it completely absorbs the light hitting it?
   a) About $3.3 \times 10^{-7}$ N
   b) About $1.1 \times 10^{-11}$ N
   c) About $3.3 \times 10^{-9}$ N
   d) About $1.1 \times 10^{-8}$ N
   e) About $3.3 \times 10^{-10}$ N

13. A ray of light goes from air into water. Which of the following is true?
   a) Its wavelength decreases
   b) Its frequency increases
   c) Its speed stays the same
   d) Its wavelength stays the same
   e) Its frequency decreases

14. See the figure for this question. A ray of light goes from air into a flat block of glass (index of refraction = 1.5) at an angle of 36° with the normal to the interface. After passing through the glass, at what angle to the normal will the ray emerge into air?
   a) 62°
   b) 23°
   c) 67°
   d) 36°
   e) The ray won’t emerge into air, because it will be totally internally reflected in the glass

15. A fish looking up at the water surface sees a circular hole surrounded by a mirror. How far below the water surface is the fish, if the radius of the hole is 2.1 m and the index of refraction of water is 1.33?
   a) About 1.8 m
   b) About 2.8 m
   c) About 2.4 m
   d) About 1.6 m
   e) About 2.1 m
16. An object is placed a distance $p$ in front of a concave mirror of focal length +3 cm. The image is on the same side of the mirror as the object, and lies 8 cm closer to the mirror than the object, i.e. the distance between the object and the image is 8 cm. In which of the following ranges does the value of $p$ lie?
   a) $8 < p \leq 11$ cm  
   b) $11 < p \leq 14$ cm  
   c) $14 < p \leq 17$ cm  
   d) $17 < p \leq 20$ cm  
   e) $p > 20$ cm

17. A convex mirror has a focal length $f < 0$. Which of the following statements about the image of a real object are true?
   - I: The image must necessarily be virtual
   - II: The image must necessarily be upright
   - III: The image must necessarily be smaller than the object

a) All three statements are false  
   b) All three statements are true  
   c) I and II are true; III is false  
   d) III is true; I and II are false  
   e) II and III are true; I is false

18. An object is placed 3 cm from a lens, the image is found to lie 12 cm from the lens, on the same side as the object. What is the focal length $f$ of the lens, and is the image upright or inverted?
   a) $f = +2.4$ cm; upright image  
   b) $f = -4.0$ cm; upright image  
   c) $f = +4.0$ cm; upright image  
   d) $f = +2.4$ cm; inverted image  
   e) $f = -2.4$ cm; inverted image

19. See the figure for this question. Three lenses are shown. Which ones are converging ($f > 0$) and which are diverging ($f < 0$)?
   a) All three are diverging  
   b) II is converging; I and III are diverging  
   c) I is converging; II and III are diverging  
   d) I and II are converging; III is diverging  
   e) I and III are converging; II is diverging
20. A diverging lens of focal length \(-10 \, cm\) is placed \(10 \, cm\) to the right of an object. Another \(10 \, cm\) to the right of this lens is placed another diverging lens, also of focal \(-10 \, cm\). Where does the final image lie?

a) \(30 \, cm\) to the right of the second lens
b) \(3.3 \, cm\) to the left of the second lens
c) \(10 \, cm\) to the right of the second lens
d) \(6.0 \, cm\) to the left of the second lens
e) \(30 \, cm\) to the left of the second lens

21. A nearsighted person is one who cannot see objects clearly beyond a certain distance. A farsighted person is one who cannot see objects clearly that are closer than a certain distance. What kinds of spectacles would correct these defects?

a) Nearsighted: diverging lens; Farsighted: converging lens
b) Nearsighted: converging lens; Farsighted: diverging lens
c) Nearsighted: converging lens; Farsighted: either kind
d) Both should use converging lenses
e) Both should use diverging lenses

22. A double-slit experiment uses a slit spacing \(d\) and light of wavelength \(\lambda\). On a screen located a long distance \(L\) away \((L >> d)\), the interference pattern shows that adjacent bright fringes are separated by a small distance \(y\). If the slit spacing is then doubled, what will be the new separation between adjacent bright fringes?

a) \(4y\)
b) \(y/2\)
c) \(y/4\)
d) \(y\)
e) \(2y\)

23. A diffraction grating of total width \(4 \, cm\) is illuminated by light of wavelength \(577 \, nm\). The second-order \((m = 2)\) maximum is formed at an angle of \(41.25^\circ\). What is the total number of slits (rulings) in the grating?

a) About 12000
b) About 23000
c) About 5000
d) About 19000
e) About 8000
24. A circular radar antenna on a navy ship radiates and receives electromagnetic waves of 0.02 m wavelength to detect two small boats located 9 km from the ship. If the small boats are 100 m apart from each other, what must be the minimum diameter of the antenna so that the boats can be distinguished as two objects?

a) About 0.45 m  
b) About 0.27 m  
c) About 1.1 m  
d) About 1.4 m  
e) About 2.2 m