ID CODE: D

Physics 202 Final Exam
May 14, 2012

Name: ................................................ Student ID: ....................... 
Section: ........................................

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Instructions:

1. Don’t forget to write down your name, student ID#, and section number. You need do this on (this page of) your test book and on your Scantron sheet as well.

2. Answer all multiple choice questions in this test book by indicating the best answer among choices. You must do this both on your test book and on your Scantron sheet. Follow instructions on the Scantron sheet on how to mark valid answers.

3. When you finish, you need to turn in both this test book and the Scantron sheet.

4. Use the blank side of question pages as additional draft spaces. An extra blank sheet is provided at the end of the test book.

5. Only one answer is allowed per problem/question. All problems have equal weight.

Constants: \( k_e = 9 \times 10^9 \text{ Nm}^2/\text{C}^2 = 1/(4\pi \varepsilon_0), \quad \varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{Nm}^2) \)
\( \mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}, \quad c = 3.0 \times 10^8 \text{ m/s} \)

Please be very careful with the first question even though the answer will not count towards your grade:

1. ENTER THE ID CODE ABOVE IN THE UPPER RIGHT CORNER
A. ID Code A
B. ID Code B
C. ID Code C
D. ID Code D
E. ID Code E
2. Three point charges, $Q_1 = 10 \mu C$, $Q_2 = 10 \mu C$, and $Q_3 = -10 \mu C$ are placed on the x axis at $x = -0.5 \text{ m}$, $0.0 \text{ m}$, and $+0.5 \text{ m}$, respectively. What is the electrostatic force on the charge at $x = 0.0 \text{ m}$?

A. 3.6 N in the –x direction
B. 3.6 N in the +x direction
C. 7.2 N in the +x direction
D. zero
E. All of above are either wrong in direction or off by more than 10% from correct values

3. A spherical conducting shell has an inner radius $R$ and an outer radius $2R$. The total charge on this conducting shell is $5q$. In addition there is a point charge $Q = 2q$ at the center of the shell. Which of the followings statements describes the charge on the conductor?

A. Due to symmetry, the $5q$ charge is distributed uniformly on the body of the shell.
B. The inner surface of the shell has 1q of the charge and the outer surface has the remaining 4q.
C. The inner surface of the shell has 4q of the charge and the outer surface has the remaining 1q.
D. The inner surface of the shell has -2q of the charge and the outer surface has +7q.
E. All 5q charges are on the inner surface of the shell.
4. As shown, the conductor at 10V contains a fully enclosed empty inner cavity (the one containing point D in the figure). What is the sign of the total charge on the conducting surface (i.e. the inner surface) that encloses this cavity?

A. Positive  
B. Negative  
C. Zero  
D. can not be determined

5. In the figure above, a test charge q of 1.0μC is placed at point C. What is the magnitude of the electric force on q? (ignore the effect of the test charge on the field).

A. 1.2μN  
B. 1.0μN  
C. 0.2 μN  
D. Zero  
E. can not be determined

6. Still in the above figure, a test charge q of charge -1.0μC is moved from point C to point B. Ignoring the effect of the test charge q on the field, what is the work done to q by the electric field in the process? (hint: pay attention to the sign.)

A. 2.0 μJ  
B. -2.0 μJ  
C. -3.0 μJ  
D. +3.0 μJ  
E. none of above or can not be determined.
7. Two incandescent (i.e. resistive) light bulbs A and B are connected in series; and it is found that bulb A is twice as bright as bulb B when connected that way. Now the two bulbs are connected in parallel instead, which of the following statements is true? (assuming the brightness of the light bulb is proportional to the power it consumes)

A. Light bulb A is still twice as bright as B  
B. Light bulb A is now half as bright as B  
C. Light bulb A is 4 times as brighter  
D. Light bulb A is 1/4 as brighter  
E. None of above.

8. As shown, a negatively charged particle of mass \( m = 1.5 \text{ kg} \) is moving along a circular (and planar) path inside a uniform magnetic field \( B = 1.0 \text{T} \) (pointing into the page). The magnitude of the particle’s charge is \( Q = 0.1 \text{ C} \). The particle has a linear speed of \( v = 2 \text{ m/s} \).

![Image](image.png)

What can we say about this particle’s motion?

A. The particle is moving clockwise along a circular path of radius \( r = 20 \text{ m} \)  
B. The particle is moving counter-clockwise along a circular path of radius \( r = 15 \text{ m} \)  
C. The particle is moving clockwise along a circular path of radius \( r = 23 \text{ m} \)  
D. The particle is moving counter-clockwise along a circular path of radius \( r = 30 \text{ m} \)  
E. The above answers are either wrong in direction or off by more than 10% in value.

9. What is the direction of the current passing through \( R \) when the switch is being closed?

![Image](image2.png)

A. Left to right  
B. Right to left
10. As shown in the figure, a circular circuit loop of area $A=100 \, \text{m}^2$ containing a resistor $R$ and a capacitor $C$ is placed inside a uniform magnetic field pointing into the page. The plane of the loop is normal to the field. The initial magnetic field strength is 2T, and at $t=0$, the field starts to decrease at a constant rate $\frac{dB}{dt}=0.1 \, \text{T/s}$. It is known that $R=100\, \Omega$, and $C=1.0 \, \mu\text{F}$.

On which side of the capacitor is positive charge being accumulated?

A. Upper side  
B. Bottom side  
C. Not enough information to determine.

11. In the above setting, what how long does it take to charge the capacitor to 60% of peak charge?

A. 92 $\mu\text{s}$  
B. 51 $\mu\text{s}$  
C. 154 $\mu\text{s}$  
D. 203 $\mu\text{s}$  
E. None of above is within 10% from the correct answer.

12. Still in the above setting, what is the maximum charge that can be charged on the capacitor?

A. $1.0\times10^{-4} \, \text{C}$  
B. $1.0\times10^{-5} \, \text{C}$  
C. $0.7\times10^{-5} \, \text{C}$  
D. $1.4\times10^{-5} \, \text{C}$  
E. None of above is within 10% from the correct answer.
13. A series RCL circuit as shown is driven by a AC power source. The AC power has a fixed voltage amplitude and a tunable frequency. If the $R=50\,\Omega$, $C=2.0\,\mu F$, $L=20\,mH$, and the voltage output of the AC source is $\Delta V=24.0\sin(6000t)$ in SI units, what is the average power consumed by this circuit?

A. 2.4 W  
B. 3.7 W  
C. 7.5 W  
D. 8.3 W  
E. none of above is within 10% of the correct answer.

14. In the above circuit, if we want to increase the (average) power consumed by the resistor from the current level, what shall we do about the frequency? (note, the voltage amplitude of the AC source is fixed).

A. Increase frequency from current setting.  
B. Decrease frequency from current setting.  
C. Turning frequency won’t help as the resistance is independent of frequency.  
D. Not enough information to determine.

15. A WI-FI access point is broadcasting signals in all directions (3D isotropic). Its total signal power is $20\,mW$. A WI-FI receiver is capable of receiving signal of minimum intensity of $2\times10^{-5}\,W/m^2$. What is the maximum distance can this receiver be away from the access point (and still functional)?

A. 9 meters  
B. 18 meters  
C. 23 meters  
D. 35 meters  
E. none of above is within 20% of the correct answer.
16. A 10.0-mW helium–neon laser emits a beam of circular cross section with a diameter of 2.95 mm. The wavelength (in vacuum) of the laser is 632.8 nm. How much energy is delivered in 100 periods of the above laser?

A. $10 \times 10^{-14} \text{ J}$
B. $2.1 \times 10^{-15} \text{ J}$
C. $1.0 \times 10^{-12} \text{ J}$
D. It can be determined but none of above is within 10% of the correct error.
E. Not enough information to determine.

17. If the above laser is shooting into pure water ($n=1.33$), what are the frequency and wavelength of the beam in water?

A. $f=4.7 \times 10^{14} \text{ Hz}$ and $\lambda=632.8 \text{ nm}$.
B. $f=3.6 \times 10^{14} \text{ Hz}$ and $\lambda=632.8 \text{ nm}$.
C. $f=3.6 \times 10^{14} \text{ Hz}$ and $\lambda=475.8 \text{ nm}$.
D. $f=4.7 \times 10^{14} \text{ Hz}$ and $\lambda=475.8 \text{ nm}$.
E. None of above are within 10% of correct values (respectively for $f$ and $\lambda$).

18. An incoming light beam (beam 1) is shooting from water ($n=1.33$) into air as shown. Which beam(s) is(are) NOT possibly resulting beam(s) after beam 1 hits the water-air surface? (Note: unless specified, the angles drawn are not exactly to the scale. Please allow nominal drawing errors).

A. Only ray 5 is not possible
B. Only Ray 5 and Ray 3 are impossible
C. After considering the possibility of total internal reflection, Ray 4 is also impossible
D. Only Ray 2 and Ray 3 are impossible.
E. None of above.
19. A ray of light travels from air into another medium, making an angle of $\theta_1 = 45.0^\circ$ with the normal as in the figure below. It is known that the speed of light in the second medium is $2.057 \times 10^8 \text{ m/s}$. Find the angle of refraction $\theta_2$.

(A) $39^\circ$
(B) $29^\circ$
(C) $33^\circ$
(D) It can be determined but none of above is within 10% of the correct answer.
(E) Not enough information to determine as the index of refraction of the 2nd medium is not given.

20. When you (your eyes) are looking at an object, the image on your retina is:

(A) always real
(B) always virtual
(C) not sure, it depends on whether you are wearing eye glasses or not
(D) not sure, it depends on whether the image is enlarged or reduced.
(E) not sure, it depends on whether the image is upright or inverted

21. We know that daylight is colorless (white). The colorful rainbow is realized due to a process called

(A) reflection
(B) refraction
(C) interference
(D) diffraction
(E) mental illusion.
22. An upright object of height 1.0cm is placed 77.2cm on the principal axis in front of a converging lens with a focal length of 10 cm. Where is the image? (Assuming no aberration)

A. 9 cm in front of the lens ("in front of" means same side as the object)
B. 9 cm behind the lens
C. 11 cm behind the lens
D. 15 cm in front of the lens
E. None of above is within 10% of the correct answer (and on the right side)

23. In the above setting, is the image

A. real and upright
B. real and inverted
C. virtual and upright
D. virtual and inverted
E. Not enough information to determine

24. Still in the above setting, the image size is

A. 0.15 cm
B. 0.75 cm
C. 1.19 cm
D. 1.75 cm
E. None of above is within 10% of the correct answer.

25. Still referring to above setting, now, a second converging lens of focal length 10 cm is placed 15 cm in parallel and behind the first lens (again, “behind” means on the other side of the object, and on the principal axis), is the final image

A. real, upright and enlarged (compared to the original object, same below)
B. real, inverted and enlarged
C. virtual, upright and reduced
D. virtual inverted and reduced
E. None of above
26. A double-slit interference experiment is illustrated as shown. Point P on the screen is the location of the 2\textsuperscript{nd} maxima of the interference pattern. If we increase the slit spacing \(d\), the distance of P from the center O (i.e. \(y\)) will

\[\text{(A)} \quad \text{decrease} \]
\[\text{(B)} \quad \text{increase proportional to } d \]
\[\text{(C)} \quad \text{increase proportional to } d^2 \]
\[\text{(D)} \quad \text{remain unchanged} \]
\[\text{(E)} \quad \text{Not enough information to determine.} \]

27. A pinhole camera is essentially a dark box with a small circular aperture. Light from distant objects passes through the aperture into an otherwise dark box, falling on a screen at the other end of the box. The aperture in a pinhole camera has diameter \(D = 0.600\) mm. When the camera is used to picture two point sources of light of wavelength 595 nm are at a distance \(L = 26\) m from the hole, what is the minimum separation between the two point sources that the camera can resolve?

\[\text{(A)} \quad 3.1\text{ cm} \]
\[\text{(B)} \quad 5.4\text{ cm} \]
\[\text{(C)} \quad 7.8\text{ cm} \]
\[\text{(D)} \quad 13\text{ m} \]
\[\text{(E)} \quad \text{None of above is within 10\% of correct answer} \]

28. A film of MgF\(_2\) (\(n = 1.38\)) is used to coat on the (front) surface of a sun glasses(\(n_{\text{glass}} = 1.6\)). What is the minimum thickness of the coating that is required to \textbf{maximize} the reflection of sun light of nominal wavelength of \(\lambda = 550\) nm (in air)? (assume sun light comes at normal angle to the glass surface.)

\[\text{(A)} \quad 100\text{ nm} \]
\[\text{(B)} \quad 200\text{ nm} \]
\[\text{(C)} \quad 400\text{ nm} \]
\[\text{(D)} \quad 800\text{ nm} \]
\[\text{(E)} \quad \text{None of above is within 10\% of correct answer} \]
29. A film of MgF2 ($n = 1.38$) is used to coat on the (front) surface of a sun glasses ($n_{glass}=1.6$). What is the minimum thickness of the coating that is required to minimize the transmission of sun light of nominal wavelength of $\lambda=550\text{nm}$ (in air)? (assume sun light comes at normal angle to the glass surface.)

A. same minimum thickness as in the previous problem.
B. double minimum thickness of that in the previous problem.
C. half minimum thickness of that in the previous problem.
D. 4 times minimum thickness of that in the previous problem.
E. None of above.

30. A thin film of oil ($n=1.5$) is floating on top of still water ($n=1.33$). A sun beam of nominal wavelength $\lambda=550\text{nm}$ (in air) is shining on it at about the normal angle to the water surface. What is the minimum thickness of the oil such that the transmission of sun light into water is minimized?

A. 92 nm
B. 184 nm
C. 367 nm
D. 734 nm
E. None of above is within 10% of correct answer

31. A polarizing disk initially has its transmission axis in parallel to the electric vector ($E_0$) of an incoming plane light of intensity $I_0$. If the disk is turned by 30 degrees, the intensity of the transmission light will become

A. $I=0.87I_0$
B. $I=0.50I_0$
C. $I=0.25I_0$
D. $I=0.75I_0$
E. None of above is within 10% of correct answer