Instructor(s): Kumar/Stewart

PHY 2054
Exam 2
November 8, 2011

Name (print, last first): ____________________________ 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.

(1) Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number). Code your name on your answer sheet. DARKEN CIRCLES COMPLETELY. Code your UFID 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. Circle your answers on the test form. 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.

(4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or some answers may be counted as incorrect.

(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.

(6) Hand in the answer sheet separately.

Useful Constants:

<table>
<thead>
<tr>
<th>$k_e$ = $8.99 \times 10^9$ Nm$^2$/C$^2$</th>
<th>$\varepsilon_0$ = $8.85 \times 10^{-12}$ C$^2$/Nm$^2$</th>
<th>$V$ = volt</th>
<th>$N$ = newton</th>
</tr>
</thead>
<tbody>
<tr>
<td>electron charge = $-1.6 \times 10^{-19}$ C</td>
<td>electron mass = $9.11 \times 10^{-31}$ kg</td>
<td>$J$ = joule</td>
<td>$m$ = Meter</td>
</tr>
<tr>
<td>“milli” = $10^{-3}$</td>
<td>“micro” = $10^{-6}$</td>
<td>$n$ = “nano” = $10^{-9}$</td>
<td>“pico” = $10^{-12}$</td>
</tr>
<tr>
<td>$1$ T = $10^4$ G</td>
<td>$G$ = $6.67 \times 10^{-11}$ Nm$^2$/kg$^2$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$B_{solenoid} = \mu_0 n I$, where $\mu_0 = 4\pi \times 10^{-7}$ Tm/A, $n$ is number of turns/m, and $I$ is current in Amperes

1. A 5 kΩ resistor in series with an uncharged capacitor ‘C’ is connected to a 9 V battery. Three seconds after the connection, the voltage across the capacitor is 3 V. What is $C$ in units of mF? (1mF=$10^{-3}$ F.)

   (1) 1.48 (2) 0.55 (3) 0.50 (4) 0.72 (5) 0.97

2. If the voltage between A and B in the figure is 12 V, how much current, in A, flows through the 2Ω resistor?

   \[ A \quad 1Ω \quad 2Ω \quad 4Ω \quad 5Ω \quad 3Ω \quad 6Ω \quad B \]

   (1) 0.81 (2) 0.61 (3) 0.71 (4) 0.91 (5) 1.01

3. What is the voltage difference between A and B, in V? (The ground, with zero potential, is at the lower left corner of the circuit.)

   \[ A \quad 6Ω \quad 1Ω \quad 9V \quad 7Ω \quad 2Ω \quad 6V \quad B \]

   (1) 1.57 (2) 0.57 (3) 1.07 (4) −0.57 (5) 10.43

4. A 6 V battery charges a capacitor through a 100Ω resistor. The capacitor in the circuit gives a charging time constant of 9 seconds. Assuming that the capacitor starts the cycle with no charge, after how much time, in seconds, after the switch to the 6V battery is closed is the charge on the capacitor = 0.5 Coulombs?

   (1) 23.4 (2) 13.4 (3) 18.4 (4) 15.9 (5) 20.9
5. A magnetic field \( B = 0.1 \, \text{T} \) directed into the paper at ‘X’ exerts a magnetic force \( F_B \) on the positive charge \( +q = 1.6 \times 10^{-19} \, \text{m} \). The centripetal force keeps the charge rotating in a circular orbit, \( r = 10^{-6} \, \text{m} \). What is the magnitude of the velocity of the positive charge, in \( \text{m/s} \)? (\( m_{\text{charge}} = 9.11 \times 10^{-31} \, \text{kg} \).

(1) \( 1.8 \times 10^4 \)  \( \)  (2) \( 1.8 \times 10^{-5} \)  \( \)  (3) \( 1.8 \times 10^6 \)  \( \)  (4) \( 1.8 \times 10^3 \)  \( \)  (5) \( 1.8 \times 10^7 \)

6. There is a 1 m long section of a conductor aligned along the y-axis with mass = \( 16 \times 10^{-3} \, \text{kg} \) in a uniform \( 0.7 \, \text{T} \) magnetic field that is pointing to the left in the \(-x\) axis direction. This x-y plane is in the plane of the test paper, and gravity is directed into the paper. What current (units of Amps) has to flow in the wire and in which direction (+ or \(-y\)-direction) for the magnetic force to be up ‘out of the paper’ on the wire to equal the downward ‘into the paper’ force of gravity (the ‘floating wire’)?

(1) \( 0.22, +y \)  \( \)  (2) \( 0.022, -y \)  \( \)  (3) \( 0.022, +y \)  \( \)  (4) \( 0.22, -y \)  \( \)  (5) \( 0.002, -y \)

7. A current of 1 Ampere flows about two loops of wire (loops A and B— the loops are pictured together but are far apart and do not interact) in the counter clockwise direction. The large half circle in each loop, centered at point P marked by the black dot, has a radius of 10 cm, while the small half circle in each loop (also centered at point P) has a radius of 5 cm. Calculate the magnetic field produced by the current at point P in both loops. What is the ratio: (field at point P in loop A/field at point P in loop B)?

(1) \( \frac{1}{3} \)  \( \)  (2) \( 3 \)  \( \)  (3) \( \frac{1}{2} \)  \( \)  (4) \( 2 \)  \( \)  (5) \( 1 \)

8. How many turns per meter should a solenoid have in order to produce a 1 T magnetic field with 100 A of current?

(1) \( 8000 \)  \( \)  (2) \( 800 \)  \( \)  (3) \( 80 \)  \( \)  (4) \( 8 \)  \( \)  (5) \( 80,000 \)

9. A 100 turn coil is arranged so a uniform 2 T external field is perpendicular to the coil (see sketch). If the circular coil has \( r = 0.1 \, \text{m} \), what is the absolute magnitude of \( V \) of the average induced voltage if the coil is turned so that it is parallel to the field after 0.01 s?

(1) \( 630 \)  \( \)  (2) \( 310 \)  \( \)  (3) \( 6300 \)  \( \)  (4) \( 3100 \)  \( \)  (5) \( 31 \)

10. A square with one loop of wire with area \( 1 \, \text{m}^2 \) is moving through space with a constant velocity of 100 m/s in a region of zero magnetic field. The loop suddenly enters a region of uniform magnetic field, \( B = 3 \, \text{T} \), that is perpendicular to the plane of the square loop. Between when the loop begins to enter the field region, and 0.01 s later, what is the magnitude of the average voltage induced in the loop, in \( V \)?

(1) \( 300 \)  \( \)  (2) \( 30 \)  \( \)  (3) \( 3 \)  \( \)  (4) \( 3000 \)  \( \)  (5) \( 30,000 \)
11. In the circuit shown in the figure, \( L = 56 \text{ mH}, R = 4.6\Omega \) and \( V = 12.0 \text{ V} \). The switch S has been open for a long time then is suddenly closed at \( t = 0 \). At what value of \( t \) (in msec) will the current in the inductor reach 1.1 A?

   (1) 6.67  
   (2) 10.5  
   (3) 2.88  
   (4) 19.9  
   (5) never

12. In the previous problem, what is the total energy stored in the inductor a long time after the switch is closed?

   (1) 0.19 J  
   (2) 0.048 J  
   (3) 0.76 J  
   (4) 0.034 J  
   (5) 0.38 J

13. In the circuit shown in the figure, \( L = 56 \text{ mH}, R = 4.6\Omega \) and \( V = 12.0 \text{ V} \). The switch S has been open for a long time then is suddenly closed at \( t = 0 \). At what value of \( t \) (in msec) will the current in the inductor reach 2.1 A?

   (1) 19.9  
   (2) 6.67  
   (3) 10.5  
   (4) 2.88  
   (5) never

14. In the previous problem, what is the total energy stored in the inductor a long time after the switch is closed?

   (1) 0.19 J  
   (2) 0.048 J  
   (3) 0.76 J  
   (4) 0.034 J  
   (5) 0.38 J

15. In the circuit shown in the figure, \( L = 56 \text{ mH}, R = 4.6\Omega \) and \( V = 12.0 \text{ V} \). The switch S has been open for a long time then is suddenly closed at \( t = 0 \). At what value of \( t \) (in msec) will the current in the inductor reach 0.57 A?

   (1) 3.0  
   (2) 6.67  
   (3) 10.5  
   (4) 19.9  
   (5) never

16. In the previous problem, what is the total energy stored in the inductor a long time after the switch is closed?

   (1) 0.19 J  
   (2) 0.048 J  
   (3) 0.76 J  
   (4) 0.034 J  
   (5) 0.38 J

17. A conducting bar can slide with no friction along two conducting rails separated by distance \( L = 0.5 \text{ m} \), as shown. A uniform 2 Tesla magnetic field points into the page, as indicated by crosses, and the resistance \( R = 0.5\Omega \). An external force \( F_{\text{app}} \) pulls the bar to the right with a constant speed \( v = 3 \text{ m/s} \). What is the power (in Watts) provided by the external force \( F_{\text{app}} \)?

   (1) 18  
   (2) 8  
   (3) 2  
   (4) 54  
   (5) 6

18. In the previous problem, what is the magnitude of the external force \( F_{\text{app}} \) (in N)?

   (1) 6  
   (2) 4  
   (3) 3  
   (4) 2  
   (5) 18
19. A conducting bar can slide with no friction along two conducting rails separated by distance \( L = 0.5 \) m, as shown. A uniform 2 Tesla magnetic field points into the page, as indicated by crosses, and the resistance \( R = 0.5 \Omega \). An external force \( F_{\text{app}} \) pulls the bar to the right with a constant speed \( v = 2 \) m/s. What is the power (in Watts) provided by the external force \( F_{\text{app}} \)?

(1) 8 (2) 18 (3) 2 (4) 54 (5) 6

20. In the previous problem, what is the magnitude of the external force \( F_{\text{app}} \) (in N)?

(1) 4 (2) 6 (3) 3 (4) 2 (5) 18

21. A conducting bar can slide with no friction along two conducting rails separated by distance \( L = 0.5 \) m, as shown. A uniform 2 Tesla magnetic field points into the page, as indicated by crosses, and the resistance \( R = 0.5 \Omega \). An external force \( F_{\text{app}} \) pulls the bar to the right with a constant speed \( v = 1 \) m/s. What is the power (in Watts) provided by the external force \( F_{\text{app}} \)?

(1) 2 (2) 8 (3) 18 (4) 54 (5) 6

22. In the previous problem, what is the magnitude of the external force \( F_{\text{app}} \) (in N)?

(1) 2 (2) 4 (3) 3 (4) 6 (5) 18

23. The remnants of a red giant star form a ring around a black hole of mass \( M = 2 \times 10^{32} \) kg, just like the rings of rock and ice around Saturn. Our home planet lies in the plane of rotation of the ring; the material on one side moves towards us, the material on the other side moves away from us. The diameter of the ring is \( D = 2.4 \times 10^{13} \) m. The Hubble space telescope observes the emission from hydrogen atoms inside the ring. Hydrogen atoms at rest emit light at 410 nm. What is the frequency difference (in \( 10^9 \) Hz=GHz) between the light emitted by Hydrogen atoms flying away from us and the light emitted by Hydrogen atoms flying towards us in the ring? Assume that the relative velocity between the black hole and earth can be neglected. Hint: Recall that the gravitational force between two masses is \( F_G = Gm_1m_2/r^2 \).

(1) 163 (2) 282 (3) 230 (4) 203 (5) 247

24. The remnants of a red giant star form a ring around a black hole of mass \( M = 4 \times 10^{32} \) kg, just like the rings of rock and ice around Saturn. Our home planet lies in the plane of rotation of the ring; the material on one side moves towards us, the material on the other side moves away from us. The diameter of the ring is \( D = 2.4 \times 10^{13} \) m. The Hubble space telescope observes the emission from hydrogen atoms inside the ring. Hydrogen atoms at rest emit light at 410 nm. What is the frequency difference (in \( 10^9 \) Hz=GHz) between the light emitted by Hydrogen atoms flying away from us and the light emitted by Hydrogen atoms flying towards us in the ring? Assume that the relative velocity between the black hole and earth can be neglected. Hint: Recall that the gravitational force between two masses is \( F_G = Gm_1m_2/r^2 \).

(1) 230 (2) 282 (3) 163 (4) 203 (5) 247

25. The remnants of a red giant star form a ring around a black hole of mass \( M = 6 \times 10^{32} \) kg, just like the rings of rock and ice around Saturn. Our home planet lies in the plane of rotation of the ring; the material on one side moves towards us, the material on the other side moves away from us. The diameter of the ring is \( D = 2.4 \times 10^{13} \) m. The Hubble space telescope observes the emission from hydrogen atoms inside the ring. Hydrogen atoms at rest emit light at 410 nm. What is the frequency difference (in \( 10^9 \) Hz=GHz) between the light emitted by Hydrogen atoms flying away from us and the light emitted by Hydrogen atoms flying towards us in the ring? Assume that the relative velocity between the black hole and earth can be neglected. Hint: Recall that the gravitational force between two masses is \( F_G = Gm_1m_2/r^2 \).

(1) 282 (2) 163 (3) 230 (4) 203 (5) 247
26. A small spherical particle with diameter 0.2 mm and density 2 g/cm³ is suspended over a table by a vertical laser beam. Assume that the particle is totally absorbing. What is the intensity of the laser beam in W/m²?

(1) $7.8 \times 10^8$  (2) $1.6 \times 10^9$  (3) 2.6  (4) $8.0 \times 10^7$  (5) $7.8 \times 10^4$

27. An object is located 20 cm from a mirror that forms a real image that is twice the size of the object. The type of mirror and its radius of curvature (in cm) must be, respectively:

(1) concave, 27  (2) convex, 27  (3) concave, 40  (4) convex, 40  (5) none of these

28. A small underwater pool light is located at the bottom of a swimming pool. The circle of light on the surface of the pool, through which the light comes out, has a radius of 1.13 m. What is the depth (in meters) of the pool? ($n_{\text{water}} = 1.333$)

(1) 1  (2) 1.5  (3) 2  (4) 2.5  (5) 3

29. A small underwater pool light is located at the bottom of a swimming pool. The circle of light on the surface of the pool, through which the light comes out, has a radius of 1.67 m. What is the depth (in meters) of the pool? ($n_{\text{water}} = 1.333$)

(1) 1.5  (2) 1  (3) 2  (4) 2.5  (5) 3

30. A small underwater pool light is located at the bottom of a swimming pool. The circle of light on the surface of the pool, through which the light comes out, has a radius of 2.27 m. What is the depth (in meters) of the pool? ($n_{\text{water}} = 1.333$)

(1) 2  (2) 1.5  (3) 1  (4) 2.5  (5) 3

31. A man standing 1.52 m in front of a shaving mirror produces an inverted image 18 cm in front of it. How close (in cm) to the mirror should he stand if he wants to form an upright image of his chin that is twice the chin’s actual size?

(1) 8.05  (2) 10.73  (3) 12.07  (4) 4.02  (5) None of these.

32. A man standing 1.52 m in front of a shaving mirror produces an inverted image 18 cm in front of it. How close (in cm) to the mirror should he stand if he wants to form an upright image of his chin that is three times the chin’s actual size?

(1) 10.73  (2) 8.05  (3) 12.07  (4) 4.02  (5) None of these.

33. A man standing 1.52 m in front of a shaving mirror produces an inverted image 18 cm in front of it. How close (in cm) to the mirror should he stand if he wants to form an upright image of his chin that is four times the chin’s actual size?

(1) 12.07  (2) 8.05  (3) 10.73  (4) 4.02  (5) None of these.

34. A narrow beam of ultrasonic waves reflects off the live tumor as shown in the figure. If the speed of the wave is 10% less in the liver than in the surrounding medium, determine the depth of the tumor in cm.

(1) 6.3  (2) 10.4  (3) 14.6  (4) 2.3  (5) none of these.
THE FOLLOWING QUESTIONS, NUMBERED IN THE ORDER OF THEIR APPEARANCE ON THE ABOVE LIST, HAVE BEEN FLAGGED AS CONTINUATION QUESTIONS: 12 14 16 18 20 22 FOLLOWING GROUPS OF QUESTIONS WILL BE SELECTED AS ONE GROUP FROM EACH TYPE

TYPE 1
Q# S 11 12
Q# S 13 14
Q# S 15 16

TYPE 2
Q# S 17 18
Q# S 19 20
Q# S 21 22

TYPE 3
Q# S 23
Q# S 24
Q# S 25

TYPE 4
Q# S 28
Q# S 29
Q# S 30

TYPE 5
Q# S 31
Q# S 32
Q# S 33