

# calc2:Study



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Tuesday 14<sup>th</sup> May, 2019

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## 1 b\_waves\_PC


1. People don't usually perceive an echo when<sup>1</sup>
  - A. it arrives less than a tenth of a second after the original sound**
  - B. it arrives at exactly the same pitch
  - C. it arrives at a higher pitch
  - D. it arrives at a lower pitch
  - E. it takes more than a tenth of a second after the original sound to arrive
2. Why do rough walls give a concert hall a fuller sound, compared to smooth walls?<sup>2</sup>
  - A. Rough walls make for a louder sound.
  - B. The difference in path lengths creates more reverberation.**
  - C. The difference in path lengths creates more echo.
3. Comparing a typical church to a professional baseball stadium, the church is likely to have<sup>3</sup>
  - A. reverberation instead of echo**
  - B. echo instead of reverberation
  - C. both reverberation and echo
  - D. neither reverberation nor echo
4. A dense rope is connected to a rope with less density (i.e. fewer kilograms per meter). If the rope is stretched and a wave is sent along high density rope towards the low density rope,<sup>4</sup>
  - A. the low density rope supports a wave with a higher frequency
  - B. the low density rope supports a wave with a lower frequency
  - C. the low density rope supports a wave with a higher speed
  - D. the low density rope supports a wave with a lower speed**
5. A low density rope is connected to a rope with higher density (i.e. more kilograms per meter). If the rope is stretched and a wave is sent along the low density rope towards the high density rope,<sup>5</sup>
  - A. the high density rope supports a wave with a higher frequency
  - B. the high density rope supports a wave with a lower frequency
  - C. the high density rope supports a wave with a higher speed**
  - D. the high density rope supports a wave with a lower speed
6. What happens to the wavelength on a wave on a stretched string if the wave passes from lightweight (low density) region of the rope to a heavy (high density) rope?<sup>6</sup>
  - A. the wavelength gets longer**
  - B. the wavelength stays the same
  - C. the wavelength gets shorter
7. When a wave is reflected off a stationary barrier, the reflected wave<sup>7</sup>
  - A. has lower amplitude than the incident wave**
  - B. has higher frequency than the incident wave
  - C. both of these are true


The next page might contain more answer choices for this question

8.  These two pulses will collide and produce<sup>8</sup>
- constructive interference
  - destructive interference**
  - constructive diffraction
  - destructive diffraction

9.  These two pulses will collide and produce<sup>9</sup>
- constructive interference**
  - destructive interference
  - constructive diffraction
  - destructive diffraction

10.  The two solid signals add to a (dashed)<sup>10</sup>
- octave**
  - fifth
  - dissonance

11.  The two solid signals add to a (dashed)<sup>11</sup>
- octave
  - fifth
  - dissonance**

12.  The two solid signals add to a (dashed)<sup>12</sup>
- octave
  - fifth**
  - dissonance

13. Why don't we hear beats when two different notes on a piano are played at the same time?<sup>13</sup>
- The beats happen so many times per second you can't hear them.**
  - The note is over by the time the first beat is heard
  - Reverberation usually stifles the beats
  - Echo usually stifles the beats

14. A tuning fork with a frequency of 440 Hz is played simultaneously with a tuning fork of 442 Hz. How many beats are heard in 10 seconds?<sup>14</sup>
- 20**
  - 30
  - 40
  - 50
  - 60

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15. If you start moving towards a source of sound, the pitch<sup>15</sup>

- A. becomes higher
- B. becomes lower
- C. remains unchanged

16. If a source of sound is moving towards you, the pitch<sup>16</sup>

- A. becomes higher
- B. becomes lower
- C. remains unchanged

## 2 a18ElectricChargeField\_findE

1. What is the magnitude of the electric field at the origin if a 1.8 nC charge is placed at  $x = 7.9$  m, and a 2.1 nC charge is placed at  $y = 7$  m?<sup>17</sup>

- A.  $2.61 \times 10^{-1}$  N/C
- B.  $3.02 \times 10^{-1}$  N/C
- C.  $3.48 \times 10^{-1}$  N/C
- D.  $4.02 \times 10^{-1}$  N/C
- E.  **$4.64 \times 10^{-1}$  N/C**

2. What angle does the electric field at the origin make with the x-axis if a 1.1 nC charge is placed at  $x = -6.5$  m, and a 1.4 nC charge is placed at  $y = -8.3$  m?<sup>18</sup>

- A.  **$3.8 \times 10^1$  degrees**
- B.  $4.39 \times 10^1$  degrees
- C.  $5.06 \times 10^1$  degrees
- D.  $5.85 \times 10^1$  degrees
- E.  $6.75 \times 10^1$  degrees

3. A dipole at the origin consists of charge  $Q$  placed at  $x = 0.5a$ , and charge of  $-Q$  placed at  $x = -0.5a$ . The absolute value of the x component of the electric field at  $(x,y) = (6a, 4a)$  is  $\beta$  kQ/a<sup>2</sup>, where  $\beta$  equals<sup>19</sup>

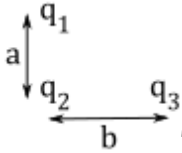
- A.  $1.33 \times 10^{-3}$
- B.  $1.61 \times 10^{-3}$
- C.  $1.95 \times 10^{-3}$
- D.  $2.37 \times 10^{-3}$
- E.  **$2.87 \times 10^{-3}$**

4. A dipole at the origin consists of charge  $Q$  placed at  $x = 0.5a$ , and charge of  $-Q$  placed at  $x = -0.5a$ . The absolute value of the y component of the electric field at  $(x,y) = (1.1a, 1.2a)$  is  $\beta$  kQ/a<sup>2</sup>, where  $\beta$  equals<sup>20</sup>

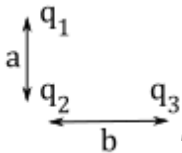
- A.  $2.36 \times 10^{-1}$
- B.  $2.86 \times 10^{-1}$
- C.  **$3.47 \times 10^{-1}$**
- D.  $4.2 \times 10^{-1}$
- E.  $5.09 \times 10^{-1}$

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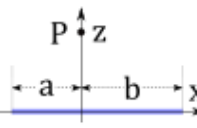
## 3 d\_cp2.5



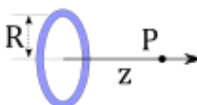
1. Three small charged objects are placed as shown, where  $b = 2a$ , and  $a = 2 \times 10^{-7}$  m. What is the magnitude of the net force on  $q_2$  if  $q_1 = 2e$ ,  $q_2 = -3e$ , and  $q_3 = 5e$ ?<sup>21</sup>
- A. 3.710E-14 N  
**B. 4.081E-14 N**  
 C. 4.489E-14 N  
 D. 4.938E-14 N  
 E. 5.432E-14 N



2. Three small charged objects are placed as shown, where  $b = 2a$ , and  $a = 2 \times 10^{-7}$  m. What angle does the force on  $q_2$  make above the  $-x$  axis if  $q_1 = 2e$ ,  $q_2 = -3e$ , and  $q_3 = 5e$ ?<sup>22</sup>
- A. 3.961E+01 degrees  
 B. 4.357E+01 degrees  
 C. 4.793E+01 degrees  
 D. 5.272E+01 degrees  
**E. 5.799E+01 degrees**

3.   $E_z(x = 0, z) = \int_{-a}^b f(x, z) dx$  is an integral that calculates the z-component of the electric field at point P situated above the x-axis where a charged rod of length  $(a+b)$  is located. The distance between point P and the x-axis is  $z = 1.5$  m. Evaluate  $f(x, y)$  at  $x = 1$  m if  $a = 0.7$  m,  $b = 1.2$  m. The total charge on the rod is 2 nC.<sup>23</sup>

- A. 2.422E+00 V/m<sup>2</sup>  
 B. 2.664E+00 V/m<sup>2</sup>  
 C. 2.931E+00 V/m<sup>2</sup>  
 D. 3.224E+00 V/m<sup>2</sup>  
**E. 3.546E+00 V/m<sup>2</sup>**

4.  A ring is uniformly charged with a net charge of 2 nC. The radius of the ring is  $R = 1.1$  m, with its center at the origin and oriented normal to the z axis as shown. What is the magnitude of the electric field at a distance  $z = 0.5$  m (on axis) away from the loop's center?<sup>24</sup>

- A. 4.210E+09 N/C<sup>2</sup>  
 B. 4.631E+09 N/C<sup>2</sup>  
**C. 5.095E+09 N/C<sup>2</sup>**

The next page might contain more answer choices for this question

- D. 5.604E+09 N/C<sup>2</sup>  
E. 6.164E+09 N/C<sup>2</sup>

5.  $E(z) = \int_0^R f(r', z) dr'$  is an integral that calculates the magnitude of the electric field at a distance  $z$  from the center of a thin circular disk as measured along a line normal to the plane of the disk. The disk's radius is  $R = 2$  m and the surface charge density is  $\sigma = 1$  nC/m<sup>2</sup>. Evaluate  $f(r', z)$  at  $r' = 1$  m.<sup>25</sup>
- A. 1.364E+01 V/m<sup>2</sup>  
B. 1.500E+01 V/m<sup>2</sup>  
C. 1.650E+01 V/m<sup>2</sup>  
D. 1.815E+01 V/m<sup>2</sup>  
**E. 1.997E+01 V/m<sup>2</sup>**
6. A large thin isolated square plate has an area of 2 m<sup>2</sup>. It is uniformly charged with 3 nC of charge. What is the magnitude of the electric field 2 mm from the center of the plate's surface?<sup>26</sup>
- A. 8.471E+01 N/C**  
B. 9.318E+01 N/C  
C. 1.025E+02 N/C  
D. 1.127E+02 N/C  
E. 1.240E+02 N/C

#### 4 c18ElectricChargeField\_lineCharges

1. A line of charge density  $\lambda$  situated on the  $y$  axis extends from  $y = -3$  to  $y = 2$ . What is the  $y$  component of the electric field at the point  $(3, 7)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{\mathcal{C} \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{B} =$ <sup>27</sup>
- A. -7  
B. -3  
C. -3  
D. 3  
**E. 2**
2. A line of charge density  $\lambda$  situated on the  $y$  axis extends from  $y = 4$  to  $y = 6$ . What is the  $y$  component of the electric field at the point  $(5, 1)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{\mathcal{C} \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{C} =$ <sup>28</sup>
- A. a) 5  
B. b) s-4  
C. c) 5-s  
**D. d) 1-s**  
E. e) s-1
3. A line of charge density  $\lambda$  situated on the  $y$  axis extends from  $y = 4$  to  $y = 6$ . What is the  $y$  component of the electric field at the point  $(5, 1)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{\mathcal{C} \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{F} =$ <sup>29</sup>
- A. 1/2  
B. 2/3  
C. 2

The next page might contain more answer choices for this question

**D. 3/2**

E. 3

4. A line of charge density  $\lambda$  situated on the x axis extends from  $x = 3$  to  $x = 7$ . What is the x component of the electric field at the point  $(7, 8)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $C =$ :<sup>30</sup>
- A.  $s-3$   
 B.  $3-s$   
 C. 8  
 D.  $s-7$   
**E.  $7-s$**
5. A line of charge density  $\lambda$  situated on the x axis extends from  $x = 3$  to  $x = 7$ . What is the x component of the electric field at the point  $(7, 8)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{D}^2 + \mathcal{E}^2 =$ :<sup>31</sup>
- A.  $7^2 + (8-s)^2$   
 B.  $7^2 + 8^2$   
**C.  $(7-s)^2 + 8^2$**   
 D.  $7^2 + (3-s)^2$   
 E.  $3^2 + 8^2$
6. A line of charge density  $\lambda$  situated on the y axis extends from  $y = -3$  to  $y = 2$ . What is the y component of the electric field at the point  $(3, 7)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $C =$ :<sup>32</sup>
- A.  $3-s$   
 B. 3  
 C.  $s-7$   
**D.  $7-s$**   
 E.  $s-3$
7. A line of charge density  $\lambda$  situated on the y axis extends from  $y = -3$  to  $y = 2$ . What is the y component of the electric field at the point  $(3, 7)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{F} =$ :<sup>33</sup>
- A. 2  
 B. 3  
**C. 3/2**  
 D. 1/2
8. A line of charge density  $\lambda$  situated on the y axis extends from  $y = 2$  to  $y = 7$ . What is the y component of the electric field at the point  $(2, 9)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $C =$ :<sup>34</sup>
- A. 2  
 B.  $s - 2$   
 C.  $2 - s$   
 D.  $s - 9$   
**E.  $9 - s$**
9. A line of charge density  $\lambda$  situated on the y axis extends from  $y = 2$  to  $y = 7$ . What is the y component of the electric field at the point  $(2, 9)$ ? *Answer* (assuming  $\mathcal{B} > \mathcal{A}$ ) is :  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[\mathcal{D}^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{D}^2 + \mathcal{E}^2 =$ :<sup>35</sup>

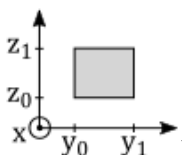
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- A.  $9^2 + (7-s)^2$
- B.  $9^2 + (2-s)^2$
- C.  $7^2 + (2-s)^2$
- D.  $2^2 + (7-s)^2$
- E.  $2^2 + (9-s)^2$

10. A line of charge density  $\lambda$  situated on the x axis extends from  $x = 4$  to  $x = 8$ . What is the y component of the electric field at the point  $(8, 4)$ ? *Answer (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[D^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{A} =$ :*<sup>36</sup>
- A. 1/2
  - B. 4
  - C. 2
  - D. 8
11. A line of charge density  $\lambda$  situated on the x axis extends from  $x = 4$  to  $x = 8$ . What is the y component of the electric field at the point  $(8, 4)$ ? *Answer (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[D^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{C} =$ :*<sup>37</sup>
- A.  $s-8$
  - B.  $8-s$
  - C.  $s-4$
  - D.  $4-s$
  - E. 4
12. A line of charge density  $\lambda$  situated on the x axis extends from  $x = 4$  to  $x = 8$ . What is the x component of the electric field at the point  $(8, 4)$ ? *Answer (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[D^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{C} =$ :*<sup>38</sup>
- A.  $s-8$
  - B.  $8-s$
  - C.  $s-4$
  - D.  $4-s$
  - E. 4
13. A line of charge density  $\lambda$  situated on the y axis extends from  $y = 4$  to  $y = 6$ . What is the x component of the electric field at the point  $(5, 1)$ ? *Answer (assuming  $\mathcal{B} > \mathcal{A}$ ) is:  $\frac{1}{4\pi\epsilon_0} \int_{\mathcal{A}}^{\mathcal{B}} \frac{C \lambda ds}{[D^2 + \mathcal{E}^2]^{\mathcal{F}}}$ , where  $\mathcal{C} =$ :*<sup>39</sup>
- A. 5
  - B.  $s-4$
  - C.  $5-s$
  - D.  $1-s$
  - E.  $s-1$

## 5 d\_cp2.6

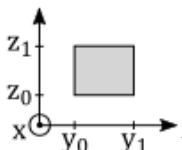


1. Each surface of the rectangular box shown is aligned with the xyz coordinate system. Two surfaces occupy identical rectangles in the planes  $x=0$  and  $x=x_1=3$  m. The other four surfaces are rectangles in  $y=y_0=1$  m,

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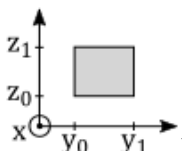
$y=y_1=5$  m,  $z=z_0=1$  m, and  $z=z_1=3$  m. The surfaces in the  $yz$  plane each have area  $8\text{m}^2$ . Those in the  $xy$  plane have area  $12\text{m}^2$ , and those in the  $zx$  plane have area  $6\text{m}^2$ . An electric field of magnitude  $10\text{N/C}$  has components in the  $y$  and  $z$  directions and is directed at  $30^\circ$  above the  $xy$ -plane (i.e. above the  $y$  axis.) What is the magnitude (absolute value) of the electric flux through a surface aligned parallel to the  $xz$  plane?<sup>40</sup>

- A.  $3.549\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- B.  $3.904\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- C.  $4.294\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- D.  $4.724\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- E.  $5.196\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$**



2. Each surface of the rectangular box shown is aligned with the  $xyz$  coordinate system. Two surfaces occupy identical rectangles in the planes  $x=0$  and  $x=x_1=3$  m. The other four surfaces are rectangles in  $y=y_0=1$  m,  $y=y_1=5$  m,  $z=z_0=1$  m, and  $z=z_1=3$  m. The surfaces in the  $yz$  plane each have area  $8\text{m}^2$ . Those in the  $xy$  plane have area  $12\text{m}^2$ , and those in the  $zx$  plane have area  $6\text{m}^2$ . An electric field of magnitude  $10\text{N/C}$  has components in the  $y$  and  $z$  directions and is directed at  $60^\circ$  from the  $z$ -axis. What is the magnitude (absolute value) of the electric flux through a surface aligned parallel to the  $xz$  plane?<sup>41</sup>

- A.  $4.724\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- B.  $5.196\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$**
- C.  $5.716\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- D.  $6.287\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- E.  $6.916\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$



3. Each surface of the rectangular box shown is aligned with the  $xyz$  coordinate system. Two surfaces occupy identical rectangles in the planes  $x=0$  and  $x=x_1=3$  m. The other four surfaces are rectangles in  $y=y_0=1$  m,  $y=y_1=5$  m,  $z=z_0=1$  m, and  $z=z_1=3$  m. The surfaces in the  $yz$  plane each have area  $8\text{m}^2$ . Those in the  $xy$  plane have area  $12\text{m}^2$ , and those in the  $zx$  plane have area  $6\text{m}^2$ . An electric field has the  $xyz$  components  $(0, 8.7, 5.0)\text{N/C}$ . What is the magnitude (absolute value) of the electric flux through a surface aligned parallel to the  $xz$  plane?<sup>42</sup>

- A.  $4.745\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- B.  $5.220\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$**
- C.  $5.742\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- D.  $6.316\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$
- E.  $6.948\text{E}+01\text{ N}\cdot\text{m}^2/\text{C}$

4. What is the magnitude (absolute value) of the electric flux through a rectangle that occupies the  $z=0$  plane with corners at  $(x,y)=(x=0,y=0)$ ,  $(x=3,y=0)$ ,  $(x=0,y=2)$ , and  $(x=3,y=2)$ , where  $x$  and  $y$  are measured in meters. The electric field is,  $\vec{E} = 1y^1\hat{i} + 2x^3\hat{j} + 3y^2\hat{k}$ .<sup>43</sup>

- A.  $1.983\text{E}+01\text{ V}\cdot\text{m}$
- B.  $2.182\text{E}+01\text{ V}\cdot\text{m}$
- C.  $2.400\text{E}+01\text{ V}\cdot\text{m}$**

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D.  $2.640\text{E}+01 \text{ V} \cdot \text{ m}$

E.  $2.904\text{E}+01 \text{ V} \cdot \text{ m}$

5. Five concentric spherical shells have radius of exactly (1m, 2m, 3m, 4m, 5m). Each is uniformly charged with 5 nano-Coulombs. What is the magnitude of the electric field at a distance of 3.5m from the center of the shells?<sup>44</sup>

**A.  $1.102\text{E}+01 \text{ N/C}$**

B.  $1.212\text{E}+01 \text{ N/C}$

C.  $1.333\text{E}+01 \text{ N/C}$

D.  $1.467\text{E}+01 \text{ N/C}$

E.  $1.613\text{E}+01 \text{ N/C}$

6. A non-conducting sphere of radius  $R=2 \text{ m}$  has a non-uniform charge density that varies with the distance from its center as given by  $\rho(r)=ar^2$  ( $r \leq R$ ) where  $a=1 \text{ nC} \cdot \text{ m}^{-1}$ . What is the magnitude of the electric field at a distance of 1 m from the center?<sup>45</sup>

A.  $1.867\text{E}+01 \text{ N/C}$

B.  $2.053\text{E}+01 \text{ N/C}$

**C.  $2.259\text{E}+01 \text{ N/C}$**

D.  $2.485\text{E}+01 \text{ N/C}$

E.  $2.733\text{E}+01 \text{ N/C}$

## 6 c19ElectricPotentialField\_GaussLaw

1. A cylinder of radius,  $R$ , and height  $H$  has a uniform charge density of  $\rho$ . The height is much less than the radius:  $H \ll R$ . The electric field at the center vanishes. What formula describes the electric field at a distance,  $z$ , on axis from the center if  $z > H/2$ ?<sup>46</sup>

A. answer:  $\epsilon_0 E = \rho z$

B. answer:  $\epsilon_0 E = H \rho$

C. answer:  $\epsilon_0 E = H \rho z$

**D. answer:  $\epsilon_0 E = H \rho / 2$**

E. answer:  $\epsilon_0 E = r \rho$

2. A cylinder of radius,  $R$ , and height  $H$  has a uniform charge density of  $\rho$ . The height is much less than the radius:  $H \ll R$ . The electric field at the center vanishes. What formula describes the electric field at a distance,  $z$ , on axis from the center if  $z < H/2$ ?<sup>47</sup>

A. answer:  $\epsilon_0 E = H \rho / 2$

B. answer:  $\epsilon_0 E = \rho z / 2$

**C. answer:  $\epsilon_0 E = \rho z$**

D. answer:  $\epsilon_0 E = H \rho$

E. answer:  $\epsilon_0 E = H \rho z$

3. A sphere has a uniform charge density of  $\rho$ , and a radius or  $R$ . What formula describes the electric field at a distance  $r > R$ ?<sup>48</sup>

A. answer:  $r^2 \epsilon_0 E = r R^2 \rho / 2$

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- B. answer:  $r^2\epsilon_0 E = R^3\rho/2$
- C. answer:  $r^2\epsilon_0 E = r^3\rho/3$
- D. answer:  $r^2\epsilon_0 E = r^3\rho/2$
- E. answer:  $r^2\epsilon_0 E = R^3\rho/3$**

4. A sphere has a uniform charge density of  $\rho$ , and a radius equal to  $R$ . What formula describes the electric field at a distance  $r < R$ ?<sup>49</sup>

- A. answer:  $r^2\epsilon_0 E = r^3\rho/2$
- B. answer:  $r^2\epsilon_0 E = R^3\rho/3$
- C. answer:  $r^2\epsilon_0 E = Rr^2\rho/3$
- D. answer:  $r^2\epsilon_0 E = r^3\rho/3$**
- E. answer:  $r^2\epsilon_0 E = R^3\rho/2$

5. A cylinder of radius,  $R$ , and height  $H$  has a uniform charge density of  $\rho$ . The height is much greater than the radius:  $H \gg R$ ?. The electric field at the center vanishes. What formula describes the electric field at a distance,  $r$ , radially from the center if  $r < R$ ?<sup>50</sup>

- A. answer:  $2R\epsilon_0 E = r^2\rho$
- B. answer:  $2r\epsilon_0 E = R^2\rho$
- C. answer:  $2\epsilon_0 E = r\rho$**
- D. answer:  $2\epsilon_0 E = R\rho$
- E. answer:  $2r^2\epsilon_0 E = R^3\rho$

6. A cylinder of radius,  $R$ , and height  $H$  has a uniform charge density of  $\rho$ . The height is much greater than the radius:  $H \gg R$ ?. The electric field at the center vanishes. What formula describes the electric field at a distance,  $r$ , radially from the center if  $r > R$ ?<sup>51</sup>

- A. answer:  $2R\epsilon_0 E = r^2\rho$
- B. answer:  $2\epsilon_0 E = r\rho$
- C. answer:  $2r\epsilon_0 E = R^2\rho$**
- D. answer:  $2r\epsilon_0 E = 2R^2\rho$
- E. answer:  $2r^2\epsilon_0 E = R^3\rho$

## 7 c19ElectricPotentialField\_SurfaceIntegral

1. A cylinder of radius,  $r=3$ , and height,  $h=4$ , is centered at the origin and oriented along the  $z$  axis. A vector field can be expressed in cylindrical coordinates as,  $\vec{F} = (2.35 + 2.57z)\rho^3\hat{\rho} + 7.45z^3\hat{z}$ . Let  $\hat{n}$  be the outward unit normal to this cylinder and evaluate  $\left| \int_{top} \vec{F} \cdot \hat{n} dA \right|$  over the top surface of the cylinder.<sup>52</sup>

- A. 1.148E+03
- B. 1.391E+03
- C. 1.685E+03**
- D. 2.042E+03
- E. 2.473E+03

2. A cylinder of radius,  $r=3$ , and height,  $h=4$ , is centered at the origin and oriented along the  $z$  axis. A vector field can be expressed in cylindrical coordinates as,  $\vec{F} = (2.35 + 2.57z)\rho^3\hat{\rho} + 7.45z^3\hat{z}$ . Let  $\hat{n}$  be the outward unit normal to this cylinder and evaluate  $\left| \int_{side} \vec{F} \cdot \hat{n} dA \right|$  over the curved side surface of the cylinder.<sup>53</sup>

The next page might contain more answer choices for this question

- A. 2.221E+03
- B. 2.690E+03
- C. 3.259E+03
- D. 3.949E+03
- E. 4.784E+03**

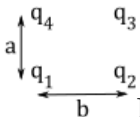
3. A cylinder of radius,  $r=3$ , and height,  $h=4$ , is centered at the origin and oriented along the  $z$  axis. A vector field can be expressed in cylindrical coordinates as,  $\vec{F} = (2.35 + 2.57z)\rho^3\hat{\rho} + 7.45z^3\hat{z}$ . Let  $\hat{n}$  be the outward unit normal to this cylinder and evaluate  $\left| \oint \vec{F} \cdot \hat{n} dA \right|$  over the entire surface of the cylinder.<sup>54</sup>

- A. 4.59E+03
- B. 5.56E+03
- C. 6.73E+03
- D. 8.15E+03**
- E. 9.88E+03

## 8 d\_cp2.7

1. A 3 C charge is separated from a 5 C charge by distance of 10 cm. What is the work done by increasing this separation to 15 cm?<sup>55</sup>

- A. 4.494E-07 J**
- B. 4.943E-07 J
- C. 5.437E-07 J
- D. 5.981E-07 J
- E. 6.579E-07 J



2. Four charges lie at the corners of a 1 cm by 1 cm square as shown (i.e., "a"="b"=1 cm.) The charges are  $q_1=2\mu\text{ C}$ ,  $q_2=3\mu\text{ C}$ ,  $q_3=4\mu\text{ C}$ , and  $q_4=5\mu\text{ C}$ . How much work was required to assemble these four charges from infinity?<sup>56</sup>

- A. 3.945E+01 J
- B. 4.339E+01 J
- C. 4.773E+01 J
- D. 5.251E+01 J
- E. 5.776E+01 J**

3. A 12.0 V battery can move 5,000 C of charge. How many Joules does it deliver?<sup>57</sup>

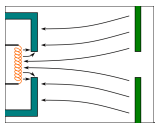
- A. 6.000E+04 J**
- B. 6.600E+04 J
- C. 7.260E+04 J
- D. 7.986E+04 J
- E. 8.785E+04 J

4. When a 12 V battery operates a 30 W bulb, how many electrons pass through it each second?<sup>58</sup>

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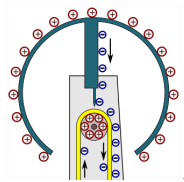
- A. 1.560E+19 electrons**
- B. 1.716E+19 electrons
- C. 1.888E+19 electrons
- D. 2.077E+19 electrons
- E. 2.285E+19 electrons

5. Calculate the final speed of a free electron accelerated from rest through a potential difference of 100 V.<sup>59</sup>
- A. 4.902E+06 m/s
  - B. 5.392E+06 m/s
  - C. 5.931E+06 m/s**
  - D. 6.524E+06 m/s
  - E. 7.176E+06 m/s



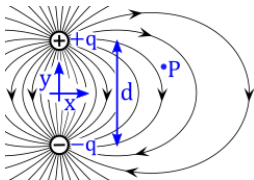
6. An electron gun has parallel plates separated by 4 cm and gives electrons 25 keV of energy. What force would the field between the plates exert on a  $0.5 \mu\text{C}$  charge that gets between the plates?<sup>60</sup>
- A. 3.125E-01 N**
  - B. 3.437E-01 N
  - C. 3.781E-01 N
  - D. 4.159E-01 N
  - E. 4.575E-01 N

7. Assume that a  $2\text{nC}$  charge is situated at the origin. Calculate the the magnitude (absolute value) of the potential difference between points  $P_1$  and  $P_2$  where the polar coordinates  $(r, \varphi)$  of  $P_1$  are  $(4\text{ cm}, 0^\circ)$  and  $P_2$  is at  $(12\text{ cm}, 24^\circ)$ .<sup>61</sup>
- A. 2.046E+02 V
  - B. 2.251E+02 V
  - C. 2.476E+02 V
  - D. 2.723E+02 V
  - E. 2.996E+02 V**



8. A Van de Graaff generator has a 25 cm diameter metal sphere that produces 100 kV near its surface. What is the excess charge on the sphere?<sup>62</sup>
- A. 1.149E+00  $\mu\text{C}$
  - B. 1.264E+00  $\mu\text{C}$
  - C. 1.391E+00  $\mu\text{C}$**
  - D. 1.530E+00  $\mu\text{C}$
  - E. 1.683E+00  $\mu\text{C}$

The next page might contain more answer choices for this question



9. A dipole has a charge magnitude of  $q=3\text{ nC}$  and a separation distance of  $d=4\text{ cm}$ . The dipole is centered at the origin and points in the  $y$ -direction as shown. What is the electric potential at the point  $(x=3\text{ cm}, y=2\text{ cm})$ ? Note that following the textbook's example, the  $y$ -value of the field point at 2 cm matches the distance of the positive charge above the  $x$ -axis.<sup>63</sup>
- A.  $3.268\text{E}+02\text{ V}$   
**B.  $3.595\text{E}+02\text{ V}$**   
 C.  $3.955\text{E}+02\text{ V}$   
 D.  $4.350\text{E}+02\text{ V}$   
 E.  $4.785\text{E}+02\text{ V}$
10. If a  $10\text{ nC}$  charge is situated at the origin, the equipotential surface for  $V(x,y,z)=100\text{ V}$  is  $x^2 + y^2 + z^2 = R^2$ , where  $R=$  <sup>64</sup>
- A.  **$8.988\text{E}-01\text{ m}$**   
 B.  $9.886\text{E}-01\text{ m}$   
 C.  $1.087\text{E}+00\text{ m}$   
 D.  $1.196\text{E}+00\text{ m}$   
 E.  $1.316\text{E}+00\text{ m}$
11. Two large parallel conducting plates are separated by  $6.5\text{ mm}$ . Equal and opposite surface charges of  $6.810\text{E}-07\text{ C/m}^2$  exist on the surfaces between the plates. What is the distance between equipotential planes which differ by  $100\text{ V}$ ?<sup>65</sup>
- A.  $8.549\text{E}-01\text{ mm}$   
 B.  $9.831\text{E}-01\text{ mm}$   
 C.  $1.131\text{E}+00\text{ mm}$   
**D.  $1.300\text{E}+00\text{ mm}$**   
 E.  $1.495\text{E}+00\text{ mm}$

## 9 a19ElectricPotentialField\_KE\_PE

1. How fast is a  $2642\text{ eV}$  electron moving?<sup>66</sup>
- A.  **$3 \times 10^7\text{ m/s}$**   
 B.  $4.6 \times 10^7\text{ m/s}$   
 C.  $6.9 \times 10^7\text{ m/s}$   
 D.  $1 \times 10^8\text{ m/s}$   
 E.  $1.5 \times 10^8\text{ m/s}$
2. A proton is accelerated (at rest) from a plate held at  $45.3\text{ volts}$  to a plate at zero volts. What is the final speed?<sup>67</sup>
- A.  $2.8 \times 10^4\text{ m/s}$   
 B.  $4.1 \times 10^4\text{ m/s}$   
 C.  $6.2 \times 10^4\text{ m/s}$

The next page might contain more answer choices for this question

**D.  $9.3 \times 10^4$  m/s.**

E.  $1.4 \times 10^5$  m/s.

3. What voltage is required to accelerate an electron at rest to a speed of  $9.4 \times 10^6$  m/s?<sup>68</sup>

A.  $7.4 \times 10^1$  volts

B.  $1.1 \times 10^2$  volts

C.  $1.7 \times 10^2$  volts

**D.  $2.5 \times 10^2$  volts**

E.  $3.8 \times 10^2$  volts

4. What voltage is required to stop a proton moving at a speed of  $8.5 \times 10^4$  m/s?<sup>69</sup>

A.  $7.4 \times 10^0$  volts

B.  $1.1 \times 10^1$  volts

C.  $1.7 \times 10^1$  volts

D.  $2.5 \times 10^1$  volts

**E.  $3.8 \times 10^1$  volts**

## 10 c07energy\_lineIntegral

1. Integrate the line integral of,  $\vec{F} = 9xy\hat{x} + 9.5y^3\hat{y}$ , along the y axis from  $y = 5$  to  $y = 14$ <sup>70</sup>

A. ) 7.33E+04

B. ) 7.84E+04

C. ) 8.39E+04

**D. ) 8.98E+04**

E. ) 9.60E+04

2. Integrate the function,  $\vec{F} = r^7\theta^9\hat{r} + r^7\theta^5\hat{\theta}$ , along the first quadrant of a circle of radius 8<sup>71</sup>

A. ) 3.43E+07

B. ) 3.67E+07

C. ) 3.93E+07

**D. ) 4.20E+07**

E. ) 4.49E+07

3. Integrate the line integral of  $\vec{F} = 4xy\hat{x} + 7.7x\hat{y}$  from the origin to the point at  $x = 2.5$  and  $y = 3.3$ <sup>72</sup>

**A. ) 5.93E+01**

B. ) 6.34E+01

C. ) 6.78E+01

D. ) 7.26E+01

E. ) 7.77E+01

4. Integrate the function,  $\vec{F} = -x^2y^2\hat{x} + x^2y^3\hat{y}$ , as a line integral around a unit square with corners at (0,0),(1,0),(1,1),(0,1). Orient the path so its direction is out of the paper by the right hand rule<sup>73</sup>

A. ) 4.45E-01

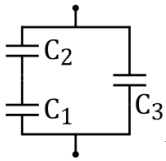
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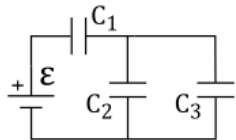
- B. ) 4.76E-01
- C. ) 5.10E-01
- D. ) 5.45E-01
- E. ) 5.83E-01**

## 11 d\_cp2.8

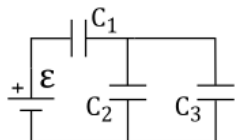
- An empty parallel-plate capacitor with metal plates has an area of  $1.0 \text{ m}^2$ , separated by  $1.0 \text{ mm}$ . How much charge does it store if the voltage is  $3.000\text{E}+03 \text{ V}$ ?<sup>74</sup>
  - A.  $2.195\text{E}+01 \mu \text{ C}$
  - B.  $2.415\text{E}+01 \mu \text{ C}$
  - C.  $2.656\text{E}+01 \mu \text{ C}$**
  - D.  $2.922\text{E}+01 \mu \text{ C}$
  - E.  $3.214\text{E}+01 \mu \text{ C}$



- What is the net capacitance if  $C_1=1 \mu \text{ F}$ ,  $C_2=5 \mu \text{ F}$ , and  $C_3=8 \mu \text{ F}$  in the configuration shown?<sup>75</sup>
  - A.  $8.030\text{E}+00 \mu \text{ F}$
  - B.  $8.833\text{E}+00 \mu \text{ F}$**
  - C.  $9.717\text{E}+00 \mu \text{ F}$
  - D.  $1.069\text{E}+01 \mu \text{ F}$
  - E.  $1.176\text{E}+01 \mu \text{ F}$



- In the figure shown  $C_1=12 \mu \text{ F}$ ,  $C_2=2 \mu \text{ F}$ , and  $C_3=4 \mu \text{ F}$ . The voltage source provides  $\epsilon = 12 \text{ V}$ . What is the charge on  $C_1$ ?<sup>76</sup>
  - A.  $3.606\text{E}+01 \mu \text{ C}$
  - B.  $3.967\text{E}+01 \mu \text{ C}$
  - C.  $4.364\text{E}+01 \mu \text{ C}$
  - D.  $4.800\text{E}+01 \mu \text{ C}$**
  - E.  $5.280\text{E}+01 \mu \text{ C}$



- In the figure shown  $C_1=12 \mu \text{ F}$ ,  $C_2=2 \mu \text{ F}$ , and  $C_3=4 \mu \text{ F}$ . The voltage source provides  $\epsilon = 12 \text{ V}$ . What is the energy stored in  $C_2$ ?<sup>77</sup>
  - A.  $1.600\text{E}+01 \mu \text{ J}$**
  - B.  $1.760\text{E}+01 \mu \text{ J}$
  - C.  $1.936\text{E}+01 \mu \text{ J}$
  - D.  $2.130\text{E}+01 \mu \text{ J}$
  - E.  $2.343\text{E}+01 \mu \text{ J}$

The next page might contain more answer choices for this question

## 12 a19ElectricPotentialField\_Capacitance

1. A parallel plate capacitor has both plates with an area of  $1.05 \text{ m}^2$ . The separation between the plates is  $0.63 \text{ mm}$ . Applied to the plates is a potential difference of  $2.85 \text{ kV}$ . What is the capacitance?<sup>78</sup>
  - A.  $8.44 \text{ nF}$ .
  - B.  $9.7 \text{ nF}$ .
  - C.  $11.16 \text{ nF}$ .
  - D.  $12.83 \text{ nF}$ .
  - E.  $14.76 \text{ nF}$ .**
2. Consider a parallel plate capacitor with area  $1.05 \text{ m}^2$ , plate separation  $0.63 \text{ mm}$ , and an applied voltage of  $2.85 \text{ kV}$ . How much charge is stored?<sup>79</sup>
  - A.  $24.05 \mu \text{ C}$ .
  - B.  $27.65 \mu \text{ C}$ .
  - C.  $31.8 \mu \text{ C}$ .
  - D.  $36.57 \mu \text{ C}$ .
  - E.  $42.06 \mu \text{ C}$ .**
3. A  $0.8 \text{ Farad}$  capacitor is charged with  $1.5 \text{ Coulombs}$ . What is the value of the electric field if the plates are  $0.7 \text{ mm}$  apart?<sup>80</sup>
  - A.  $1.76 \text{ kV/m}$ .
  - B.  $2.03 \text{ kV/m}$ .
  - C.  $2.33 \text{ kV/m}$ .
  - D.  $2.68 \text{ kV/m}$ .**
  - E.  $3.08 \text{ kV/m}$ .
4. A  $0.8 \text{ Farad}$  capacitor is charged with  $1.5 \text{ Coulombs}$ . What is the energy stored in the capacitor if the plates are  $0.7 \text{ mm}$  apart?<sup>81</sup>
  - A.  $0.8 \text{ J}$ .
  - B.  $0.92 \text{ J}$ .
  - C.  $1.06 \text{ J}$ .
  - D.  $1.22 \text{ J}$ .
  - E.  $1.41 \text{ J}$ .**
5. A  $0.8 \text{ Farad}$  capacitor is charged with  $1.5 \text{ Coulombs}$ . What is the force between the plates if they are  $0.7 \text{ mm}$  apart?<sup>82</sup>
  - A.  $2009 \text{ N}$ .**
  - B.  $2310 \text{ N}$ .
  - C.  $2657 \text{ N}$ .
  - D.  $3055 \text{ N}$ .
  - E.  $3514 \text{ N}$ .

The next page might contain more answer choices for this question

**13 d\_cp2.9**

1. What is the average current involved when a truck battery sets in motion 720 C of charge in 4 s while starting an engine? <sup>83</sup>
  - A. 1.229E+02 A
  - B. 1.352E+02 A
  - C. 1.488E+02 A
  - D. 1.636E+02 A
  - E. 1.800E+02 A**
2. The charge passing a plane intersecting a wire is  $Q(t) = Q_0 (1 - e^{-t/\tau})$ , where  $Q_0=10\text{ C}$  and  $\tau =0.02\text{ s}$ . What is the current at  $t =1.000\text{E-}02\text{ s}$ ?<sup>84</sup>
  - A. 2.506E+02 A
  - B. 2.757E+02 A
  - C. 3.033E+02 A**
  - D. 3.336E+02 A
  - E. 3.670E+02 A
3. Calculate the drift speed of electrons in a copper wire with a diameter of 2.053 mm carrying a 20 A current, given that there is one free electron per copper atom. The density of copper is  $8.80 \times 10^3\text{ kg/m}^3$  and the atomic mass of copper is 63.54 g/mol. Avagadro's number is  $6.02 \times 10^{23}\text{ atoms/mol}$ .<sup>85</sup>
  - A. 4.111E-04 m/s
  - B. 4.522E-04 m/s**
  - C. 4.974E-04 m/s
  - D. 5.472E-04 m/s
  - E. 6.019E-04 m/s
4. A make-believe metal has a density of  $8.800\text{E}+03\text{ kg/m}^3$  and an atomic mass of 63.54 g/mol. Taking Avogadro's number to be  $6.020\text{E}+23\text{ atoms/mol}$  and assuming one free electron per atom, calculate the number of free electrons per cubic meter.<sup>86</sup>
  - A.  $5.695\text{E}+28\text{ e}^-/\text{m}^3$
  - B.  $6.264\text{E}+28\text{ e}^-/\text{m}^3$
  - C.  $6.890\text{E}+28\text{ e}^-/\text{m}^3$
  - D.  $7.579\text{E}+28\text{ e}^-/\text{m}^3$
  - E.  $8.337\text{E}+28\text{ e}^-/\text{m}^3$**
5. A device requires consumes 100 W of power and requires 0.87 A of current which is supplied by a single core 10-guage (2.588 mm diameter) wire. Find the magnitude of the average current density.<sup>87</sup>
  - A.  $1.367\text{E}+05\text{ A/m}^2$
  - B.  $1.504\text{E}+05\text{ A/m}^2$
  - C.  $1.654\text{E}+05\text{ A/m}^2$**
  - D.  $1.819\text{E}+05\text{ A/m}^2$
  - E.  $2.001\text{E}+05\text{ A/m}^2$

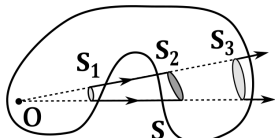
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6. Calculate the resistance of a 12-gauge copper wire that is 5 m long and carries a current of 10 mA. The resistivity of copper is  $1.680\text{E-}08 \Omega \cdot \text{m}$  and 12-gauge wire as a cross-sectional area of  $3.31 \text{ mm}^2$ .<sup>88</sup>
- A.  $1.907\text{E-}02 \Omega$
  - B.  $2.097\text{E-}02 \Omega$
  - C.  $2.307\text{E-}02 \Omega$
  - D.  $2.538\text{E-}02 \Omega$**
  - E.  $2.792\text{E-}02 \Omega$
7. Calculate the electric field in a 12-gauge copper wire that is 5 m long and carries a current of 10 mA. The resistivity of copper is  $1.680\text{E-}08 \Omega \cdot \text{m}$  and 12-gauge wire as a cross-sectional area of  $3.31 \text{ mm}^2$ .<sup>89</sup>
- A.  $5.076\text{E-}05 \text{ V/m}$**
  - B.  $5.583\text{E-}05 \text{ V/m}$
  - C.  $6.141\text{E-}05 \text{ V/m}$
  - D.  $6.756\text{E-}05 \text{ V/m}$
  - E.  $7.431\text{E-}05 \text{ V/m}$
8. Imagine a substance could be made into a very hot filament. Suppose the resistance is  $3.5 \Omega$  at a temperature of  $20^\circ\text{C}$  and that the temperature coefficient of expansion is  $4.500\text{E-}03 (\text{ }^\circ\text{C})^{-1}$ . What is the resistance at a temperature of  $2.850\text{E+}03 \text{ }^\circ\text{C}$ ?<sup>90</sup>
- A.  $4.578\text{E+}01 \Omega$
  - B.  $4.807\text{E+}01 \Omega$**
  - C.  $5.048\text{E+}01 \Omega$
  - D.  $5.300\text{E+}01 \Omega$
  - E.  $5.565\text{E+}01 \Omega$
9. A DC winch motor draws 20 amps at 115 volts as it lifts a  $4.900\text{E+}03 \text{ N}$  weight at a constant speed of  $0.333 \text{ m/s}$ . Assuming that all the electrical power is either converted into gravitational potential energy or ohmically heats the motor's coils, calculate the coil's resistance.<sup>91</sup>
- A.  $1.255\text{E+}00 \Omega$
  - B.  $1.381\text{E+}00 \Omega$
  - C.  $1.519\text{E+}00 \Omega$
  - D.  $1.671\text{E+}00 \Omega$**
  - E.  $1.838\text{E+}00 \Omega$
10. What is consumer cost to operate one 100-W incandescent bulb for 3 hours per day for 1 year (365 days) if the cost of electricity is  $\$0.1$  per kilowatt-hour?<sup>92</sup>
- A.  $\$8.227\text{E+}00$
  - B.  $\$9.050\text{E+}00$
  - C.  $\$9.955\text{E+}00$
  - D.  $\$1.095\text{E+}01$**
  - E.  $\$1.205\text{E+}01$

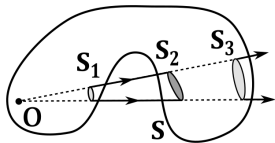
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## 14 d\_cp2.gaussC

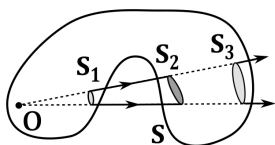
- If Gauss' law can be reduced to an algebraic expression that easily calculates the electric field ( $\epsilon_0 EA^* = \rho V^*$ ),  $\vec{E}$  was calculated inside the Gaussian surface<sup>93</sup>
  - True
  - False**
- If Gauss' law can be reduced to an algebraic expression that easily calculates the electric field ( $\epsilon_0 EA^* = \rho V^*$ ),  $\vec{E}$  was calculated outside the Gaussian surface<sup>94</sup>
  - True
  - False**
- If Gauss' law can be reduced to an algebraic expression that easily calculates the electric field ( $\epsilon_0 EA^* = \rho V^*$ ),  $\vec{E}$  was calculated on the Gaussian surface<sup>95</sup>
  - True**
  - False
- If Gauss' law can be reduced to an algebraic expression that easily calculates the electric field ( $\epsilon_0 EA^* = \rho V^*$ ),  $\vec{E}$  had<sup>96</sup>
  - constant direction and magnitude over the entire Gaussian surface
  - constant magnitude over a portion of the Gaussian surface**
  - constant direction over a portion of the Gaussian surface
  - constant in direction over the entire Gaussian surface



- In this description of the flux element,  $d\vec{S} = \hat{n}dA_j$  ( $j=1,2,3$ ) where  $\hat{n}$  is the outward unit normal, and a positive charge is assumed at point "O", inside the Gaussian surface shown. The field lines exit at  $S_1$  and  $S_3$  but enter at  $S_2$ . In this figure,  $dA_1 = dA_3$ <sup>97</sup>
  - True
  - False**



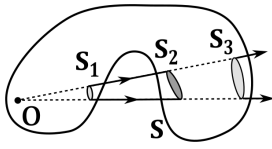
- In this description of the flux element,  $d\vec{S} = \hat{n}dA_j$  ( $j=1,2,3$ ) where  $\hat{n}$  is the outward unit normal, and a positive charge is assumed at point "O", inside the Gaussian surface shown. The field lines exit at  $S_1$  and  $S_3$  but enter at  $S_2$ . In this figure,  $\vec{E}_1 \cdot d\vec{A}_1 = \vec{E}_3 \cdot d\vec{A}_3$ <sup>98</sup>
  - True**
  - False



- In this description of the flux element,  $d\vec{S} = \hat{n}dA_j$  ( $j=1,2,3$ ) where  $\hat{n}$  is the outward unit normal, and a positive charge is assumed at point "O", inside the Gaussian surface shown. The field lines exit at  $S_1$  and  $S_3$  but enter at  $S_2$ . In this figure,  $\vec{E}_1 \cdot d\vec{A}_1 + \vec{E}_3 \cdot d\vec{A}_3 = 0$ <sup>99</sup>

The next page might contain more answer choices for this question

- A. True  
**B. False**



8. In this description of the flux element,  $d\vec{S} = \hat{n}dA_j$  ( $j=1,2,3$ ) where  $\hat{n}$  is the outward unit normal, and a positive charge is assumed at point "O", inside the Gaussian surface shown. The field lines exit at  $S_1$  and  $S_3$  but enter at  $S_2$ . In this figure,  $\vec{E}_1 \cdot d\vec{A}_1 + \vec{E}_2 \cdot d\vec{A}_3 = 0$  <sup>100</sup>

- A. True**  
 B. False

## 15 a20ElectricCurrentResistivityOhm\_PowerDriftVel

- A 4 volt battery moves 27 Coulombs of charge in 2.6 hours. What is the power?<sup>101</sup>
  - $7.86 \times 10^{-3}$  W
  - $9.52 \times 10^{-3}$  W
  - $1.15 \times 10^{-2}$  W**
  - $1.4 \times 10^{-2}$  W
  - $1.69 \times 10^{-2}$  W
- The diameter of a copper wire is 5.5 mm, and it carries a current of 76 amps. What is the drift velocity if copper has a density of  $8.8\text{E}3 \text{ kg/m}^3$  and an atomic mass of 63.54 g/mol? (1 mol =  $6.02\text{E}23$  atoms, and copper has one free electron per atom.)<sup>102</sup>
  - $1.35 \times 10^{-4}$  m/s
  - $1.63 \times 10^{-4}$  m/s
  - $1.98 \times 10^{-4}$  m/s
  - $2.39 \times 10^{-4}$  m/s**
  - $2.9 \times 10^{-4}$  m/s
- A 168 Watt DC motor draws 0.3 amps of current. What is effective resistance?<sup>103</sup>
  - $1.87 \times 10^3 \Omega$**
  - $2.26 \times 10^3 \Omega$
  - $2.74 \times 10^3 \Omega$
  - $3.32 \times 10^3 \Omega$
  - $4.02 \times 10^3 \Omega$
- A power supply delivers 113 watts of power to a 104 ohm resistor. What was the applied voltage?<sup>104</sup>
  - $5.03 \times 10^1$  volts
  - $6.1 \times 10^1$  volts
  - $7.39 \times 10^1$  volts
  - $8.95 \times 10^1$  volts
  - $1.08 \times 10^2$  volts**

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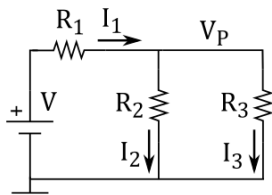
## 16 d\_cp2.10

- A given battery has a 12 V emf and an internal resistance of  $0.1 \Omega$ . If it is connected to a  $0.5 \Omega$  resistor what is the power dissipated by that load?<sup>105</sup>

  - 1.503E+02 W
  - 1.653E+02 W
  - 1.818E+02 W
  - 2.000E+02 W**
  - 2.200E+02 W
- A battery with a terminal voltage of 9 V is connected to a circuit consisting of 4  $20 \Omega$  resistors and one  $10 \Omega$  resistor. What is the voltage drop across the  $10 \Omega$  resistor?<sup>106</sup>

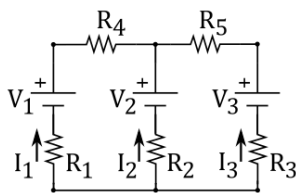
  - 7.513E-01 V
  - 8.264E-01 V
  - 9.091E-01 V
  - 1.000E+00 V**
  - 1.100E+00 V
- Three resistors,  $R_1 = 1 \Omega$ , and  $R_2 = R_3 = 2 \Omega$ , are connected in parallel to a 3 V voltage source. Calculate the power dissipated by the smaller resistor ( $R_1$ ).<sup>107</sup>

  - 6.762E+00 W
  - 7.438E+00 W
  - 8.182E+00 W
  - 9.000E+00 W**
  - 9.900E+00 W



- In the circuit shown  $V=12 \text{ V}$ ,  $R_1=1 \Omega$ ,  $R_2=6 \Omega$ , and  $R_3=13 \Omega$ . What is the power dissipated by  $R_2$ ?<sup>108</sup>

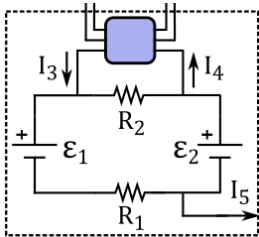
  - 1.552E+01 W**
  - 1.707E+01 W
  - 1.878E+01 W
  - 2.066E+01 W
  - 2.272E+01 W



- The resistances in the figure shown are  $R_1 = 2 \Omega$ ,  $R_2 = 1 \Omega$ , and  $R_3 = 3 \Omega$ .  $V_1$  and  $V_3$  are text 0.5 V and 2.3 V, respectively. But  $V_2$  is opposite to that shown in the figure, or, equivalently,  $V_2 = -0.6 \text{ V}$ . What is the absolute value of the current through  $R_1$ ?<sup>109</sup>

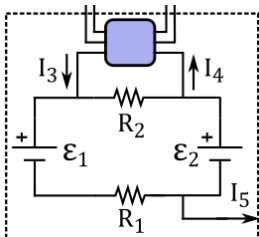
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- A. 1.653E-01 A
- B. 1.818E-01 A
- C. 2.000E-01 A**
- D. 2.200E-01 A
- E. 2.420E-01 A



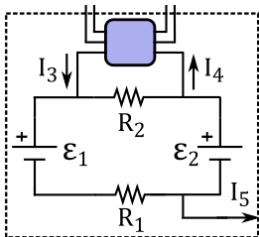
6. Two sources of emf  $\epsilon_1=22.5\text{ V}$ , and  $\epsilon_2=10\text{ V}$  are oriented as shown in the circuit. The resistances are  $R_1=2\text{ k}\Omega$  and  $R_2=1\text{ k}\Omega$ . Three other currents enter and exit or exit from portions of the circuit that lie outside the dotted rectangle and are not shown.  $I_3=5.0\text{ mA}$  and  $I_4=1.25\text{ mA}$  enter and leave near  $R_2$ , while the current  $I_5$  exits near  $R_1$ . What is the magnitude (absolute value) of  $I_5$ ?<sup>110</sup>

- A. 3.099E+00 mA
- B. 3.409E+00 mA
- C. 3.750E+00 mA**
- D. 4.125E+00 mA
- E. 4.538E+00 mA



7. Two sources of emf  $\epsilon_1=22.5\text{ V}$ , and  $\epsilon_2=10\text{ V}$  are oriented as shown in the circuit. The resistances are  $R_1=2\text{ k}\Omega$  and  $R_2=1\text{ k}\Omega$ . Three other currents enter and exit or exit from portions of the circuit that lie outside the dotted rectangle and are not shown.  $I_3=5.0\text{ mA}$  and  $I_4=1.25\text{ mA}$  enter and leave near  $R_2$ , while the current  $I_5$  exits near  $R_1$ . What is the magnitude (absolute value) of voltage drop across  $R_1$ ?<sup>111</sup>

- A. 5.000E+00 V**
- B. 5.500E+00 V
- C. 6.050E+00 V
- D. 6.655E+00 V
- E. 7.321E+00 V

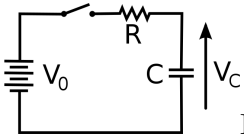


8. Two sources of emf  $\epsilon_1=22.5\text{ V}$ , and  $\epsilon_2=10\text{ V}$  are oriented as shown in the circuit. The resistances are  $R_1=2\text{ k}\Omega$  and  $R_2=1\text{ k}\Omega$ . Three other currents enter and exit or exit from portions of the circuit that lie outside the dotted rectangle and are not shown.  $I_3=5.0\text{ mA}$  and  $I_4=1.25\text{ mA}$  enter and leave near  $R_2$ , while the current  $I_5$  exits near  $R_1$ . What is the magnitude (absolute value) of voltage drop across  $R_2$ ?<sup>112</sup>

The next page might contain more answer choices for this question



- A. 6.198E+00 V
- B. 6.818E+00 V
- C. 7.500E+00 V**
- D. 8.250E+00 V
- E. 9.075E+00 V



9. In the circuit shown the voltage across the capacitor is zero at time  $t=0$  when a switch is closed putting the capacitor into contact with a power supply of 100 V. If the combined external and internal resistance is  $101\ \Omega$  and the capacitance is 50 mF, how long will it take for the capacitor's voltage to reach 80 V?<sup>113</sup>

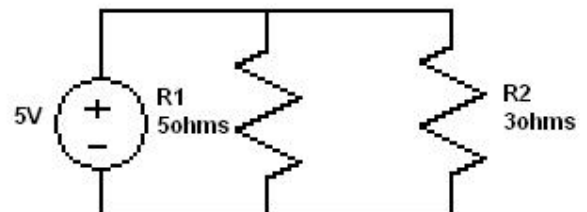
- A. 8.128E+00 s**
- B. 8.940E+00 s
- C. 9.834E+00 s
- D. 1.082E+01 s
- E. 1.190E+01 s

## 17 a21CircuitsBioInstDC\_circAnalQuiz1

1. 3 amps flow through a 1 Ohm resistor. What is the voltage?<sup>114</sup>
  - A. 3V.**
  - B. 1V.
  - C.  $\frac{1}{3}V$ .
  - D. None these are correct.
2. A 1 ohm resistor has 5 volts DC across its terminals. What is the current (I) and the power consumed?<sup>115</sup>
  - A.  $I = 5A$  &  $P = 3W$ .
  - B.  $I = 5A$  &  $P = 5W$ .
  - C.  $I = 5A$  &  $P = 25W$ .**
  - D.  $I = 5A$  &  $P = 9W$ .
3. The voltage across two resistors in series is 10 volts. One resistor is twice as large as the other. What is the voltage across the larger resistor? What is the voltage across the smaller one? <sup>116</sup>
  - A.  $V_{Big-Resistor} = 3.33V$  and  $V_{small-Resistor} = 6.67V$ .
  - B.  $V_{small-Resistor} = 5V$  and  $V_{Big-Resistor} = 5V$ .
  - C.  $V_{Big-Resistor} = 6.67V$  and  $V_{small-Resistor} = 3.33V$ .**
  - D. None of these are true.
4. A 1 ohm, 2 ohm, and 3 ohm resistor are connected in series. What is the total resistance?<sup>117</sup>
  - A.  $R_{Total} = 0.5454\Omega$ .
  - B.  $R_{Total} = 3\Omega$ .
  - C.  $R_{Total} = 6\Omega$ .**
  - D. None of these are true.

The next page might contain more answer choices for this question

5. Two identical resistors are connected in series. The voltage across both of them is 250 volts. What is the voltage across each one?<sup>118</sup>
- $R_1 = 150V$  and  $R_2 = 100V$ .
  - None of these are true.
  - $R_1 = 125V$  and  $R_2 = 125V$ .
  - $R_1 = 250V$  and  $R_2 = 0V$ .
6. A 1 ohm, 2 ohm, and 3 ohm resistor are connected in "parallel". What is the total resistance?<sup>119</sup>
- $\frac{11}{6}\Omega$ .
  - $\frac{3}{6}\Omega$ .
  - $\frac{6}{11}\Omega$ .
  - $\frac{6}{3}\Omega$ .
7. A 5 ohm and a 2 ohm resistor are connected in parallel. What is the total resistance?<sup>120</sup>
- $\frac{6}{10}\Omega$ .
  - $\frac{7}{10}\Omega$ .
  - $\frac{10}{6}\Omega$ .
  - $\frac{10}{7}\Omega$ .
8. A 7 ohm and a 3 ohm resistor are connected in parallel. What is the total resistance?<sup>121</sup>
- $\frac{21}{10}\Omega$ .
  - $\frac{11}{7}\Omega$ .
  - $\frac{7}{11}\Omega$ .
  - $\frac{10}{21}\Omega$ .
9. Three 1 ohm resistors are connected in parallel. What is the total resistance?<sup>122</sup>
- $3\Omega$ .
  - $\frac{1}{3}\Omega$ .
  - $\frac{3}{2}\Omega$ .
  - $\frac{2}{3}\Omega$ .
10. If you put an infinite number of resistors in parallel. Under ideal conditions (no wire or contact resistance), what would the total resistance be?<sup>123</sup>
- $R_{total}$  would approach zero.
  - $R_{total}$  would approach the value of a single resistor.
  - $R_{total}$  would approach infinity.

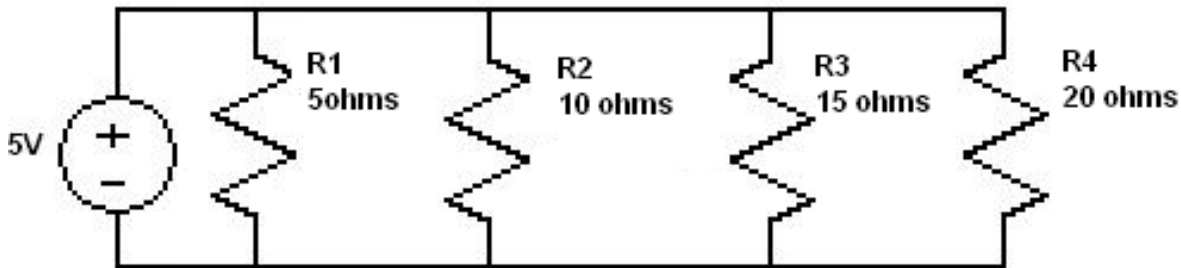


11. What is the current through R1 and R2 in the figure shown?

- A.  $I_1 = 0.1A$  and  $I_2 = 0.1667A$ .
- B.  $I_1 = 10A$  and  $I_2 = 16.67A$ .
- C.  $I_1 = 1A$  and  $I_2 = 25A$ .
- D.  $I_1 = 1A$  and  $I_2 = 1.667A$ .

12. Why do we say the "voltage across" or "the voltage with respect to?" Why can't we just say voltage?<sup>125</sup>
- A. It's an Electrical "Cliche".
  - B. The other point could be Negative or positive.
  - C. None these are correct.
  - D. **Voltage is a measure of Electric Potential difference between two electrical points.**

13. What is the current through R1, R2, R3, and R4 in the figure shown?



126

- A.  $I_1 = 10A$ ;  $I_2 = 50A$ ;  $I_3 = 33A$ ;  $I_4 = 25A$ .
- B.  $I_1 = 1A$ ;  $I_2 = 5A$ ;  $I_3 = 3.3A$ ;  $I_4 = 2.5A$ .
- C.  $I_1 = 1A$ ;  $I_2 = 0.5A$ ;  $I_3 = 0.33A$ ;  $I_4 = 0.25A$ .
- D.  $I_1 = 0.25A$ ;  $I_2 = 0.33A$ ;  $I_3 = 0.5A$ ;  $I_4 = 0.1A$ .

14. Two resistors are in parallel with a voltage source. How do their voltages compare?<sup>127</sup>
- A. **The voltage across both resistors is the same as the source.**
  - B. None of these are true.
  - C. One has full voltage, the other has none.
  - D. The voltage across both resistors is half the voltage of the source.

15. A resistor consumes 5 watts, and its current is 10 amps. What is its voltage?<sup>128</sup>
- A. 2V.
  - B. 10V.
  - C. **0.5V.**
  - D. 15V.

16. A resistor has 10 volts across it and 4 amps going through it. What is its resistance?<sup>129</sup>
- A. None of these are true.
  - B.  $3.5\Omega$ .
  - C.  $4.5\Omega$ .
  - D.  $2.5\Omega$ .

17. If you plot voltage vs. current in a circuit, and you get a linear line, what is the significance of the slope? <sup>130</sup>

The next page might contain more answer choices for this question

- A. Power.
- B. Resistance.**
- C. Discriminant.
- D. None of these are true.

18. A resistor has 3 volts across it. Its resistance is 1.5 ohms. What is the current?<sup>131</sup>
- A. 12A.
  - B. 3A.
  - C. 2A.**
  - D. 1.5A.
19. A resistor has 8 volts across it and 3 Amps going through it. What is the power consumed?<sup>132</sup>
- A. 2.2 W.
  - B. 24 W.**
  - C. 8 W.
  - D. 3 W.
20. A resistor has a voltage of 5 volts and a resistance of 15 ohms. What is the power consumed? <sup>133</sup>
- A. None of these are ture.
  - B. 11.67 Joules
  - C. 1.67 Watts**
  - D. 2.5 Watts
21. A resistor is on for 5 seconds. It consumes power at a rate of 5 watts. How many joules are used?<sup>134</sup>
- A. 25 Joules**
  - B. 3 Joules
  - C. 5 Joules
  - D. None of these are true

## 18 a21CircuitsBioInstDC\_circuits

1. An ideal 5.2 V voltage source is connected to two resistors in series. One is  $1.2k\Omega$ , and the other is  $2.8k\Omega$ . What is the current through the larger resistor?<sup>135</sup>
- A. 0.7 mA.
  - B. 0.9 mA.
  - C. 1.1 mA.
  - D. 1.3 mA.**
  - E. 1.5 mA.
2. A 7.7 ohm resistor is connected in series to a pair of 5.8 ohm resistors that are in parallel. What is the net resistance?<sup>136</sup>
- A. 6.1 ohms.
  - B. 7 ohms.
  - C. 8 ohms.

The next page might contain more answer choices for this question

- D. 9.2 ohms.  
**E. 10.6 ohms.**
3. Two 8 ohm resistors are connected in parallel. This combination is then connected in series to a 6.6 ohm resistor. What is the net resistance?<sup>137</sup>
- A. 9.2 ohms.  
**B. 10.6 ohms.**  
C. 12.2 ohms.  
D. 14 ohms.  
E. 16.1 ohms.
4. An ideal 7.9 volt battery is connected to a 0.09 ohm resistor. To measure the current an ammeter with a resistance of  $20m\Omega$  is used. What current does the ammeter actually read?<sup>138</sup>
- A. 71.8 A.**  
B. 82.6 A.  
C. 95 A.  
D. 109.2 A.  
E. 125.6 A.
5. A battery has an emf of 5.3 volts, and an internal resistance of  $326 k\Omega$ . It is connected to a  $3 M\Omega$  resistor. What power is developed in the  $3 M\Omega$  resistor?<sup>139</sup>
- A.  $5.01 \mu\text{W}$ .  
B.  $5.76 \mu\text{W}$ .  
C.  $6.62 \mu\text{W}$ .  
**D.  $7.62 \mu\text{W}$ .**  
E.  $8.76 \mu\text{W}$ .

## 19 a21CircuitsBioInstDC\_RCdecaySimple

1. A 621 mF capacitor is connected in series to a 628 k $\Omega$  resistor. If the capacitor is discharged, how long does it take to fall by a factor of  $e^3$ ? (where  $e = 2.7\dots$ )<sup>140</sup>
- A.  $1.17 \times 10^5$  s.  
B.  $3.7 \times 10^5$  s.  
**C.  $1.17 \times 10^6$  s.**  
D.  $3.7 \times 10^6$  s.  
E.  $1.17 \times 10^7$  s.
2. A 784  $\mu$  F capacitor is connected in series to a 543 k $\Omega$  resistor. If the capacitor is discharged, how long does it take to fall by a factor of  $e^3$ ? (where  $e = 2.7\dots$ )<sup>141</sup>
- A.  $4.04 \times 10^1$  s.  
B.  $1.28 \times 10^2$  s.  
C.  $4.04 \times 10^2$  s.  
**D.  $1.28 \times 10^3$  s.**  
E.  $4.04 \times 10^3$  s.

The next page might contain more answer choices for this question

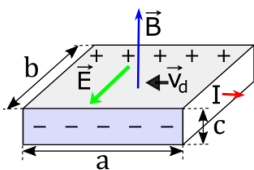
3. A 354 mF capacitor is connected in series to a 407 M $\Omega$  resistor. If the capacitor is discharged, how long does it take to fall by a factor of  $e^3$ ? (where  $e = 2.7...$ )<sup>142</sup>
- A.  $4.32 \times 10^7$  s.
  - B.  $1.37 \times 10^8$  s.
  - C.  $4.32 \times 10^8$  s.**
  - D.  $1.37 \times 10^9$  s.
  - E.  $4.32 \times 10^9$  s.
4. A 10 F capacitor is connected in series to a 9 $\Omega$  resistor. If the capacitor is discharged, how long does it take to fall by a factor of  $e^4$ ? (where  $e = 2.7...$ )<sup>143</sup>
- A.  $3.6 \times 10^2$  s.**
  - B.  $1.14 \times 10^3$  s.
  - C.  $3.6 \times 10^3$  s.
  - D.  $1.14 \times 10^4$  s.
  - E.  $3.6 \times 10^4$  s.

## 20 d\_cp2.11

1. An alpha-particle ( $q=3.2 \times 10^{-19}$ C) moves through a uniform magnetic field that is parallel to the positive z-axis with magnitude 1.5 T. What is the x-component of the force on the alpha-particle if it is moving with a velocity  $(2.2 \mathbf{i} + 3.3 \mathbf{j} + 1.1 \mathbf{k}) \times 10^4$  m/s?<sup>144</sup>
- A. 1.440E-14 N
  - B. 1.584E-14 N**
  - C. 1.742E-14 N
  - D. 1.917E-14 N
  - E. 2.108E-14 N
2. A charged particle in a magnetic field of 1.000E-04 T is moving perpendicular to the magnetic field with a speed of 5.000E+05 m/s. What is the period of orbit if orbital radius is 0.5 m?<sup>145</sup>
- A. 4.721E-06 s
  - B. 5.193E-06 s
  - C. 5.712E-06 s
  - D. 6.283E-06 s**
  - E. 6.912E-06 s
3. An alpha-particle ( $m=6.64 \times 10^{-27}$ kg,  $q=3.2 \times 10^{-19}$ C) briefly enters a uniform magnetic field of magnitude 0.05 T. It emerges after being deflected by 45° from its original direction. How much time did it spend in that magnetic field?<sup>146</sup>
- A. 3.259E-07 s**
  - B. 3.585E-07 s
  - C. 3.944E-07 s
  - D. 4.338E-07 s
  - E. 4.772E-07 s

The next page might contain more answer choices for this question

4. A 50 cm-long horizontal wire is maintained in static equilibrium by a horizontally directed magnetic field that is perpendicular to the wire (and to Earth's gravity). The mass of the wire is 10 g, and the magnitude of the magnetic field is 0.5 T. What current is required to maintain this balance?<sup>147</sup>
- A. **3.920E-01 A**  
 B. 4.312E-01 A  
 C. 4.743E-01 A  
 D. 5.218E-01 A  
 E. 5.739E-01 A
5. A long rigid wire carries a 5 A current. What is the magnetic force per unit length on the wire if a 0.3 T magnetic field is directed 60° away from the wire?<sup>148</sup>
- A. 1.074E+00 N/m  
 B. 1.181E+00 N/m  
 C. **1.299E+00 N/m**  
 D. 1.429E+00 N/m  
 E. 1.572E+00 N/m
6. A circular current loop of radius 2 cm carries a current of 2 mA. What is the magnitude of the torque if the dipole is oriented at 30° to a uniform magnetic field of 0.5 T? <sup>149</sup>
- A. 4.292E-07 N m  
 B. 4.721E-07 N m  
 C. 5.193E-07 N m  
 D. 5.712E-07 N m  
 E. **6.283E-07 N m**
7. An electron beam ( $m=9.1 \times 10^{-31}$  kg,  $q=1.6 \times 10^{-19}$  C) enters a crossed-field velocity selector with magnetic and electric fields of 2 mT and 6.000E+03 N/C, respectively. What must the velocity of the electron beam be to transverse the crossed fields undeflected? <sup>150</sup>
- A. 2.254E+06 m/s  
 B. 2.479E+06 m/s  
 C. 2.727E+06 m/s  
 D. **3.000E+06 m/s**  
 E. 3.300E+06 m/s



8. The silver ribbon shown are  $a=3.5$  cm,  $b=2$  cm, and  $c=0.2$  cm. The current carries a current of 100 A and it lies in a uniform magnetic field of 1.5 T. Using the density of  $5.900\text{E}+28$  electrons per cubic meter for silver, find the Hall potential between the edges of the ribbon.<sup>151</sup>
- A. 5.419E-06 V  
 B. 5.961E-06 V  
 C. 6.557E-06 V

The next page might contain more answer choices for this question

- D. 7.213E-06 V  
**E. 7.934E-06 V**

9. A cyclotron used to accelerate alpha particles ( $m=6.64 \times 10^{-27} \text{ kg}$ ,  $q=3.2 \times 10^{-19} \text{ C}$ ) has a radius of 0.5 m and a magnetic field of 1.8 T. What is their maximum kinetic energy?<sup>152</sup>
- A. **3.904E+01 MeV**  
B. 4.294E+01 MeV  
C. 4.723E+01 MeV  
D. 5.196E+01 MeV  
E. 5.715E+01 MeV

## 21 a22Magnetism\_forces

1. A cosmic ray alpha particle encounters Earth's magnetic field at right angles to a field of  $5.7 \mu \text{ T}$ . The kinetic energy is 361 keV. What is the radius of particle's orbit?<sup>153</sup>
- A.  $1.5 \times 10^2 \text{ m}$ .  
B.  $4.8 \times 10^2 \text{ m}$ .  
C.  $1.5 \times 10^3 \text{ m}$ .  
D.  $4.8 \times 10^3 \text{ m}$ .  
**E.  $1.5 \times 10^4 \text{ m}$ .**
2. Two parallel wires are 7.2 meters long, and are separated by 6.9 mm. What is the force if both wires carry a current of 13.7 amps?<sup>154</sup>
- A.  $1.24 \times 10^{-2} \text{ newtons}$   
**B.  $3.92 \times 10^{-2} \text{ newtons}$**   
C.  $1.24 \times 10^{-1} \text{ newtons}$   
D.  $3.92 \times 10^{-1} \text{ newtons}$   
E.  $1.24 \times 10^0 \text{ newtons}$
3. Blood is flowing at an average rate of 21.5 cm/s in an artery that has an inner diameter of 3.5 mm. What is the voltage across a hall probe placed across the inner diameter of the artery if the perpendicular magnetic field is 0.11 Tesla?<sup>155</sup>
- A.  $8.28 \times 10^{-6} \text{ Volts}$   
B.  $2.62 \times 10^{-5} \text{ Volts}$   
**C.  $8.28 \times 10^{-5} \text{ Volts}$**   
D.  $2.62 \times 10^{-4} \text{ Volts}$   
E.  $8.28 \times 10^{-4} \text{ Volts}$
4. An electron tube on Earth's surface is oriented horizontally towards magnetic north. The electron is traveling at  $0.07c$ , and Earth's magnetic field makes an angle of 22.5 degrees with respect to the horizontal. To counter the magnetic force, a voltage is applied between two large parallel plates that are 54 mm apart. What must be the applied voltage if the magnetic field is  $45 \mu \text{ T}$ ?<sup>156</sup>
- A.  $2 \times 10^{-1} \text{ volts}$   
B.  $6.2 \times 10^{-1} \text{ volts}$   
C.  $2 \times 10^0 \text{ volts}$   
D.  $6.2 \times 10^0 \text{ volts}$   
**E.  $2 \times 10^1 \text{ volts}$**

The next page might contain more answer choices for this question



## 22 d\_cp2.12

1. A wire carries a current of 200 A in a circular arc with radius 2 cm swept through 40 degrees. Assuming that the rest of the current is 100% shielded by mu-metal, what is the magnetic field at the center of the arc?<sup>157</sup>

- A. 2.083E+00 Tesla
- B. 2.292E+00 Tesla**
- C. 2.521E+00 Tesla
- D. 2.773E+00 Tesla
- E. 3.050E+00 Tesla

2      3



2. 1      P Three wires sit at the corners of a square of length 1 cm. The currents all are in the positive-z direction (i.e. all come out of the paper in the figure shown.) The currents ( $I_1, I_2, I_3$ ) are (1.9 A, 2.0 A, 2.1 A), respectively. What is the x-component of the magnetic field at point P?<sup>158</sup>

- A.  $B_x = 5.124E-05$  T
- B.  $B_x = 5.636E-05$  T
- C.  $B_x = 6.200E-05$  T**
- D.  $B_x = 6.820E-05$  T
- E.  $B_x = 7.502E-05$  T

2      3



3. 1      P Three wires sit at the corners of a square of length 1 cm. The currents all are in the positive-z direction (i.e. all come out of the paper in the figure shown.) The currents ( $I_1, I_2, I_3$ ) are (1.9 A, 2.0 A, 2.1 A), respectively. What is the y-component of the magnetic field at point P?<sup>159</sup>

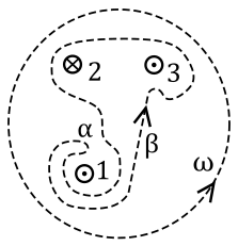
- A.  $B_y = 5.273E-05$  T
- B.  $B_y = 5.800E-05$  T**
- C.  $B_y = 6.380E-05$  T
- D.  $B_y = 7.018E-05$  T
- E.  $B_y = 7.720E-05$  T

4. Two parallel wires each carry a 5.0 mA current and are oriented in the z direction. The first wire is located in the x-y plane at (3.0 cm, 0.9 cm), while the other is located at (0.000E+00 cm, 4.0 cm). What is the force per unit length between the wires?<sup>160</sup>

- A. 7.916E-11 N/m
- B. 8.708E-11 N/m
- C. 9.579E-11 N/m
- D. 1.054E-10 N/m
- E. 1.159E-10 N/m**

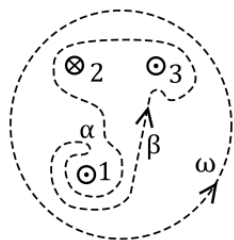
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5. Two loops of wire carry the same current of 10 kA, and flow in the same direction. They share a common axis and orientation. One loop has a radius of 0.5 m while the other has a radius of 1.0 m. What is the magnitude of the magnetic field at a point on the axis of both loops, situated between the loops at a distance 0.25 m from the first (smaller) loop if the distance between the loops is 1.0 m?<sup>161</sup>
- A. 1.110E-02 T  
**B. 1.221E-02 T**  
 C. 1.343E-02 T  
 D. 1.477E-02 T  
 E. 1.625E-02 T
6. Under most conditions the current is distributed uniformly over the cross section of the wire. What is the magnetic field 0.8 mm from the center of a wire of radius 2 mm if the current is 1A?<sup>162</sup>
- A. 2.732E-05 T  
 B. 3.005E-05 T  
 C. 3.306E-05 T  
 D. 3.636E-05 T  
**E. 4.000E-05 T**
7. The Z-pinch is an (often unstable) cylindrical plasma in which a axial magnetic field is produced by a current in the z direction. A simple model for the magnetic field, valid for  $r < a$  is,  $B_{\theta}(r) = \left(\frac{2r}{a} - \frac{r^2}{a^2}\right) B_{max}$ , where  $B_{max}$  is the maximum magnetic field (at  $r = a$ ). If  $a = 0.5$  m and  $B_{max} = 0.3$  T, then how much current (in the z-direction) flows through a circle of radius  $r = 0.25$  m that is centered on the axis with its plane perpendicular to the axis?<sup>163</sup>
- A. 2.812E+05 A**  
 B. 3.094E+05 A  
 C. 3.403E+05 A  
 D. 3.743E+05 A  
 E. 4.118E+05 A



8. The numbers (1,2,3) in the figure shown represent three currents flowing in or out of the page:  $I_1$  and  $I_3$  flow out of the page, and  $I_2$  flows into the page, as shown. Two closed paths are shown, labeled  $\beta$  and  $\omega$ . If  $I_1=2.5$  kA,  $I_2=0.75$  kA, and  $I_3=1.5$  kA, take the  $\beta$  path and evaluate the line integral,  $\oint \vec{B} \cdot d\vec{\ell}$ .<sup>164</sup>
- A. 6.437E-04 T-m  
 B. 7.081E-04 T-m  
 C. 7.789E-04 T-m  
 D. 8.568E-04 T-m  
**E. 9.425E-04 T-m**

The next page might contain more answer choices for this question



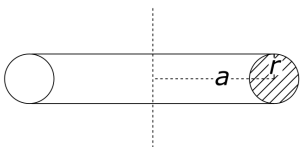
9. The numbers (1,2,3) in the figure shown represent three currents flowing in or out of the page:  $I_1$  and  $I_3$  flow out of the page, and  $I_2$  flows into the page, as shown. Two closed paths are shown, labeled  $\beta$  and  $\omega$ . If  $I_1=2.5$  kA,  $I_2=0.75$  kA, and  $I_3=1.5$  kA, take the  $\omega$  path and evaluate the line integral,  $\oint \vec{B} \cdot d\vec{\ell}$ .<sup>165</sup>
- 3.713E-03 T-m
  - 4.084E-03 T-m**
  - 4.492E-03 T-m
  - 4.942E-03 T-m
  - 5.436E-03 T-m
10. A solenoid has  $3.000\text{E}+04$  turns wound around a cylinder of diameter 1.2 cm and length 14 m. The current through the coils is 0.41 A. Define the origin to be the center of the solenoid and neglect end effects as you calculate the line integral  $\int \vec{B} \cdot \vec{\ell}$  along the axis from  $z=-2$  cm to  $z=+8$  cm.<sup>166</sup>
- 7.541E-05 T-m
  - 8.295E-05 T-m
  - 9.124E-05 T-m
  - 1.004E-04 T-m
  - 1.104E-04 T-m**
11. A long coil is tightly wound around a (hypothetical) ferromagnetic cylinder. If  $n=20$  turns per centimeter and the current applied to the solenoid is 200 mA, the net magnetic field is measured to be 1.4 T. What is the magnetic susceptibility for this case?<sup>167</sup>
- $\chi$  (chi) = 2.301E+03
  - $\chi$  (chi) = 2.531E+03
  - $\chi$  (chi) = 2.784E+03**
  - $\chi$  (chi) = 3.063E+03
  - $\chi$  (chi) = 3.369E+03

## 23 c22Magnetism\_ampereLaw

- Amper's law for a magnetostatic current is,  $\oint \vec{H} \cdot d\vec{\ell} = \int \vec{J} \cdot d\vec{A}$ , which equals the current enclosed by the closed loop, and  $B = \mu_0 H$  is the magnetic field. A current of 8.5A flows upward along the  $z$  axis. Noting that for this geometry,  $\oint \vec{B} \cdot d\vec{\ell} = B \oint d\ell$ , calculate the line integral  $\oint d\ell$  for a circle of radius 4.7m.<sup>168</sup>
  - 2.69E+01 m
  - 2.95E+01 m**
  - 3.24E+01 m
  - 3.55E+01 m
  - 3.89E+01 m

The next page might contain more answer choices for this question

2. If  $H = B/\mu_0$ , where  $B$  is magnetic field, what is  $H$  at a distance of 4.7m from a wire carrying a current of 8.5A?<sup>169</sup>
- A. 2.63E-01 A/m
  - B. 2.88E-01 A/m**
  - C. 3.16E-01 A/m
  - D. 3.46E-01 A/m
  - E. 3.79E-01 A/m
3. If  $H = B/\mu_0$ , where  $B$  is magnetic field, what is  $H_y$  at the point (3.4389,3.2037) if a current of 8.5A flows through a wire that runs along the z axis?<sup>170</sup>
- A. 1.46E-01 A/m
  - B. 1.60E-01 A/m
  - C. 1.75E-01 A/m
  - D. 1.92E-01 A/m
  - E. 2.11E-01 A/m**
4. A very long and thin solenoid has 1331 turns and is 140 meters long. The wire carries a current of 9.6A. What is the magnetic field in the center?<sup>171</sup>
- A. 8.70E-05 Tesla
  - B. 9.54E-05 Tesla
  - C. 1.05E-04 Tesla
  - D. 1.15E-04 Tesla**
  - E. 1.26E-04 Tesla
5. A very long and thin solenoid has 1770 turns and is 140 meters long. The wire carries a current of 9.6A. If this solenoid is sufficiently thin, what is the line integral of  $\int \vec{H} \cdot d\vec{\ell}$  along an on-axis path that starts 25 meters from the center and stops 98 meters from the center?<sup>172</sup>
- A. 4.54E+03 A
  - B. 4.98E+03 A
  - C. 5.46E+03 A**
  - D. 5.99E+03 A
  - E. 6.57E+03 A



6. A torus is centered around the x-y plane, with major radius,  $a = 1.56$  m, and minor radius,  $r = 0.65$  m. A wire carrying 4.4A is uniformly wrapped with 890 turns. If  $B = \mu_0 H$  is the magnetic field, what is  $H$  inside the torus, at a point on the xy plane that is 0.26m from the outermost edge of the torus?<sup>173</sup>
- A. 2.22E+02 amps per meter
  - B. 2.40E+02 amps per meter**
  - C. 2.59E+02 amps per meter
  - D. 2.79E+02 amps per meter
  - E. 3.02E+02 amps per meter

The next page might contain more answer choices for this question

## 24 c22Magnetism\_ampereLawSymmetry

- H is defined by,  $B = \mu_0 H$ , where B is magnetic field. A current of 48A passes along the z-axis. Use symmetry to find the integral,  $\int \vec{H} \cdot d\vec{\ell}$ , from the point (0, 6.7) to the point (6.7, 0).<sup>174</sup>
  - 9.10E+00 amps
  - 9.98E+00 amps
  - 1.09E+01 amps
  - 1.20E+01 amps**
  - 1.32E+01 amps
- H is defined by,  $B = \mu_0 H$ , where B is magnetic field. A current of 67A passes along the z-axis. Use symmetry to find the integral,  $\int \vec{H} \cdot d\vec{\ell}$ , from the point (-6.1, 6.1) to the point (6.1, 6.1).<sup>175</sup>
  - 1.27E+01 amps
  - 1.39E+01 amps
  - 1.53E+01 amps
  - 1.68E+01 amps**
  - 1.84E+01 amps
- H is defined by,  $B = \mu_0 H$ , where B is magnetic field. A current of 84A passes along the z-axis. Use symmetry to find the integral,  $\int \vec{H} \cdot d\vec{\ell}$ , from the point (0, 9.3) to the point (9.3, 9.3).<sup>176</sup>
  - 1.05E+01 amps**
  - 1.15E+01 amps
  - 1.26E+01 amps
  - 1.38E+01 amps
  - 1.52E+01 amps
- H is defined by,  $B = \mu_0 H$ , where B is magnetic field. A current of 81A passes along the z-axis. Use symmetry to find the integral,  $\int \vec{H} \cdot d\vec{\ell}$ , from  $(-\infty, 6.4)$  to  $(+\infty, 6.4)$ .<sup>177</sup>
  - 3.37E+01 amps
  - 3.69E+01 amps
  - 4.05E+01 amps**
  - 4.44E+01 amps
  - 4.87E+01 amps

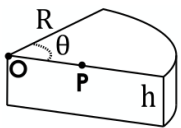
## 25 d\_cp2.13

- A square coil has sides that are  $L = 0.25$  m long and is tightly wound with  $N = 200$  turns of wire. The resistance of the coil is  $R = 5 \Omega$ . The coil is placed in a spatially uniform magnetic field that is directed perpendicular to the face of the coil and whose magnitude is increasing at a rate  $dB/dt = 0.04$  T/s. If R represents the only impedance of the coil, what is the magnitude of the current circulating through it? <sup>178</sup>
  - 1.000E-01 A**
  - 1.100E-01 A
  - 1.210E-01 A
  - 1.331E-01 A

The next page might contain more answer choices for this question

E. 1.464E-01 A

2. A time dependent magnetic field is directed perpendicular to the plane of a circular coil with a radius of 0.5 m. The magnetic field is spatially uniform but decays in time according to  $(1.5)e^{-\alpha t}$  at time  $t = 0.05$  seconds, and  $\alpha = 5\text{ s}^{-1}$ . What is the current in the coil if the impedance of the coil is  $10\ \Omega$ ?<sup>179</sup>
- A. 3.791E-01 A  
 B. 4.170E-01 A  
**C. 4.588E-01 A**  
 D. 5.046E-01 A  
 E. 5.551E-01 A
3. The current through the windings of a solenoid with  $n = 2.000\text{E}+03$  turns per meter is changing at a rate  $dI/dt = 3\text{ A/s}$ . The solenoid is 50 cm long and has a cross-sectional diameter of 3 cm. A small coil consisting of  $N = 20$  turns wrapped in a circle of diameter 1 cm is placed in the middle of the solenoid such that the plane of the coil is perpendicular to the central axis of the solenoid. Assume that the infinite-solenoid approximation is valid inside the small coil. What is the emf induced in the coil?<sup>180</sup>
- A. 9.788E-06 V  
 B. 1.077E-05 V  
**C. 1.184E-05 V**  
 D. 1.303E-05 V  
 E. 1.433E-05 V
4. Calculate the motional emf induced along a 20 km conductor moving at an orbital speed of 7.8 km/s perpendicular to Earth's  $5.000\text{E}-05$  Tesla magnetic field.<sup>181</sup>
- A. 7.091E+03 V  
**B. 7.800E+03 V**  
 C. 8.580E+03 V  
 D. 9.438E+03 V  
 E. 1.038E+04 V

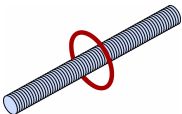


5. A cylinder of height 1.1 cm and radius 3.1 cm is cut into a wedge as shown. Now imagine that the volume grows as  $\theta$  increases while the radius  $R$  and height  $h$  remains constant. What is the volume's rate of change if point  $P$  is 2.1 cm from point  $O$  and moves at a speed of 5.1 cm/s? Assume that the wedge grows in such a way as the front face moves by rotating around the axis (that contains point  $O$ ).<sup>182</sup>
- A. 8.767E+00  $\text{cm}^3/\text{s}$   
 B. 9.644E+00  $\text{cm}^3/\text{s}$   
 C. 1.061E+01  $\text{cm}^3/\text{s}$   
 D. 1.167E+01  $\text{cm}^3/\text{s}$   
**E. 1.284E+01  $\text{cm}^3/\text{s}$**
6. A rectangular coil with an area of  $0.5\text{ m}^2$  and 10 turns is placed in a uniform magnetic field of 1.5 T. The coil is rotated about an axis that is perpendicular to this field. At time  $t = 0$  the normal to the coil is oriented parallel to the magnetic field and the coil is rotating with a constant angular frequency of  $2.000\text{E}+03\text{ s}^{-1}$ . What is the "magnitude" (absolute value) of the induced emf at  $t = 50\text{ s}$ ?<sup>183</sup>

The next page might contain more answer choices for this question

- A. 4.029E+02 V  
 B. 4.432E+02 V  
 C. 4.875E+02 V  
**D. 5.362E+02 V**  
 E. 5.899E+02 V
7. A spatially uniform magnetic points in the z-direction and oscillates with time as  $\vec{B}(t) = B_0 \sin \omega t$  where  $B_0 = 1.5$  T and  $\omega = 2.000\text{E}+03 \text{ s}^{-1}$ . Suppose the electric field is always zero at point  $\mathcal{O}$ , and consider a circle of radius 0.5 m that is centered at that point and oriented in a plane perpendicular to the magnetic field. Evaluate the maximum value of the line integral  $\oint \vec{E} \cdot d\vec{s}$  around the circle.<sup>184</sup>
- A. 9.425E+03 V  
 B. 1.037E+04 V  
 C. 1.140E+04 V  
 D. 1.254E+04 V  
 E. 1.380E+04 V
8. A long solenoid has a radius of 0.7 m and 50 turns per meter; its current decreases with time according to  $I_0 e^{-\alpha t}$ , where  $I_0 = 3$  A and  $\alpha = 25 \text{ s}^{-1}$ . What is the induced electric field at a distance 2.0 m from the axis at time  $t = 0.04$  s?<sup>185</sup>
- A. 2.124E-04 V/m  
 B. 2.336E-04 V/m  
 C. 2.570E-04 V/m  
 D. 2.827E-04 V/m  
 E. 3.109E-04 V/m
9. A long solenoid has a radius of 0.7 m and 50 turns per meter; its current decreases with time according to  $I_0 e^{-\alpha t}$ , where  $I_0 = 3$  A and  $\alpha = 25 \text{ s}^{-1}$ . What is the induced electric field at a distance 0.15 m from the axis at time  $t = 0.04$  s?<sup>186</sup>
- A. 1.300E-04 V/m  
 B. 1.430E-04 V/m  
 C. 1.573E-04 V/m  
 D. 1.731E-04 V/m  
 E. 1.904E-04 V/m

## 26 d\_cp2.14



1. A long solenoid has a length 0.75 meters, radius 3.1 cm, and 500 turns. It surrounds coil of radius 5.9 meters and 10 turns. If the current in the solenoid is changing at a rate of 200 A/s, what is the emf induced in the surrounding coil?<sup>187</sup>
- A. 1.445E-02 V  
**B. 1.589E-02 V**  
 C. 1.748E-02 V

The next page might contain more answer choices for this question

D. 1.923E-02 V

E. 2.115E-02 V

2. An induced emf of 2.0V is measured across a coil of 50 closely wound turns while the current through it increases uniformly from 0.0 to 5.0A in 0.1s. What is the self-inductance of the coil?<sup>188</sup>

A. 3.306E-02 H

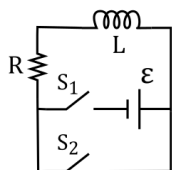
B. 3.636E-02 H

**C. 4.000E-02 H**

D. 4.400E-02 H

E. 4.840E-02 H

3. A washer has an inner diameter of 2.5 cm and an outer diameter of 4.5 cm. The thickness is  $h = Cr^{-n}$  where  $r$  is measured in cm,  $C = 3.5mm$ , and  $n = 2.7$ . What is the volume of the washer?<sup>189</sup>

A. 6.191E-01 cm<sup>3</sup>B. 6.810E-01 cm<sup>3</sup>C. 7.491E-01 cm<sup>3</sup>D. 8.240E-01 cm<sup>3</sup>**E. 9.065E-01 cm<sup>3</sup>**

4. Suppose switch  $S_1$  is suddenly closed at time  $t=0$  in the figure shown. What is the current at  $t = 2.0$  s if  $\epsilon = 2.0$  V,  $R = 4.0 \Omega$ , and  $L = 4.0$  H?<sup>190</sup>

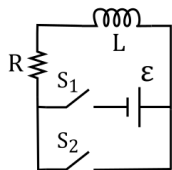
A. 3.603E-01 V

**B. 4.323E-01 V**

C. 5.188E-01 V

D. 6.226E-01 V

E. 7.471E-01 V



5. Suppose switch  $S_1$  in the figure shown was closed and remained closed long enough to achieve steady state. At  $t=0$   $S_1$  is opened as  $S_2$  is closed. How long will it take for the energy stored in the inductor to be reduced to 1.0% of its maximum value if  $\epsilon = 2.0$  V,  $R = 4.0 \Omega$ , and  $L = 4.0$  H?<sup>191</sup>

A. -1.730E+00 s

B. -1.903E+00 s

C. -2.093E+00 s

**D. -2.303E+00 s**

E. -2.533E+00 s

6. In an LC circuit, the self-inductance is 0.02 H and the capacitance is 8.000E-06 F. At  $t=0$  all the energy is stored in the capacitor, which has a charge of 1.200E-05 C. How long does it take for the capacitor to become completely discharged?<sup>192</sup>

The next page might contain more answer choices for this question



- A. **6.283E-04 s**
- B. 6.912E-04 s
- C. 7.603E-04 s
- D. 8.363E-04 s
- E. 9.199E-04 s

## 27 d\_cp2.15

1. An ac generator produces an emf of amplitude 10 V at a frequency of 60 Hz. What is the maximum amplitude of the current if the generator is connected to a 15 mF inductor?<sup>193</sup>
  - A. 1.208E+00 A
  - B. 1.329E+00 A
  - C. 1.461E+00 A
  - D. 1.608E+00 A
  - E. **1.768E+00 A**
2. An ac generator produces an emf of amplitude 10 V at a frequency of 60 Hz. What is the maximum amplitude of the current if the generator is connected to a 10 mF capacitor?<sup>194</sup>
  - A. **3.770E-02 A**
  - B. 4.147E-02 A
  - C. 4.562E-02 A
  - D. 5.018E-02 A
  - E. 5.520E-02 A
3. The output of an ac generator connected to an RLC series combination has a frequency of 200 Hz and an amplitude of 0.1 V;. If  $R = 4 \Omega$  ,  $L = 3.00\text{E-}03\text{H}$  , and  $C = 8.00\text{E-}04\text{F}$  , what is the impedance?<sup>195</sup>
  - A. 4.024E+00  $\Omega$
  - B. 4.426E+00  $\Omega$
  - C. **4.868E+00  $\Omega$**
  - D. 5.355E+00  $\Omega$
  - E. 5.891E+00  $\Omega$
4. The output of an ac generator connected to an RLC series combination has a frequency of 200 Hz and an amplitude of 0.1 V;. If  $R = 4 \Omega$  ,  $L = 3.00\text{E-}03\text{H}$  , and  $C = 8.00\text{E-}04\text{F}$  , what is the magnitude (absolute value) of the phase difference between current and emf?<sup>196</sup>
  - A. 5.514E-01 rad
  - B. **6.066E-01 rad**
  - C. 6.672E-01 rad
  - D. 7.339E-01 rad
  - E. 8.073E-01 rad
5. The output of an ac generator connected to an RLC series combination has a frequency of 1.00E+04 Hz and an amplitude of 4 V. If  $R = 5 \Omega$  ,  $L = 2.00\text{E-}03\text{H}$  , and  $C = 4.00\text{E-}06\text{F}$  , what is the rms power transferred to the resistor?<sup>197</sup>

The next page might contain more answer choices for this question

- A. 7.273E-01 Watts  
**B. 8.000E-01 Watts**  
 C. 8.800E-01 Watts  
 D. 9.680E-01 Watts  
 E. 1.065E+00 Watts
6. An RLC series combination is driven with an applied voltage of  $V = V_0 \sin(\omega t)$ , where  $V_0 = 0.1 \text{ V}$ . The resistance, inductance, and capacitance are  $R = 4 \Omega$ ,  $L = 3.00\text{E-}03\text{H}$ , and  $C = 8.00\text{E-}04\text{F}$ , respectively. What is the amplitude of the current?<sup>198</sup>
- A. 2.066E-02 A  
 B. 2.273E-02 A  
**C. 2.500E-02 A**  
 D. 2.750E-02 A  
 E. 3.025E-02 A
7. The quality factor  $Q$  is a dimensionless parameter involving the relative values of the magnitudes of the at three impedances ( $R, X_L, X_C$ ). Since  $Q$  is calculated at resonance,  $X_L, X_C$  and only two impedances are involved,  $Q = \omega_0 L / R$  is defined so that  $Q$  is large if the resistance is low. Calculate the  $Q$  of an LRC series driven at resonance by an applied voltage of  $V = V_0 \sin(\omega t)$ , where  $V_0 = 4 \text{ V}$ . The resistance, inductance, and capacitance are  $R = 0.2 \Omega$ ,  $L = 4.00\text{E-}03\text{H}$ , and  $C = 2.00\text{E-}06\text{F}$ , respectively.<sup>199</sup>
- A.  $Q = 1.278\text{E}+02$   
 B.  $Q = 1.470\text{E}+02$   
 C.  $Q = 1.691\text{E}+02$   
 D.  $Q = 1.944\text{E}+02$   
**E.  $Q = 2.236\text{E}+02$**
8. A step-down transformer steps 12 kV down to 240 V. The high-voltage input is provided by a  $200 \Omega$  power line that carries 2 A of current. What is the output current (at the 240 V side)?<sup>200</sup>
- A. 1.000E+02 A**  
 B. 1.100E+02 A  
 C. 1.210E+02 A  
 D. 1.331E+02 A  
 E. 1.464E+02 A

## 28 a23InductionACcircuits\_Q1

1. Two orbiting satellites are orbiting at a speed of 85 km/s perpendicular to a magnetic field of  $56 \mu \text{ T}$ . They are connected by a cable that is 29 km long. A voltmeter is attached between a satellite and one end of the cable. The voltmeter's internal impedance far exceeds the net resistance through the ionosphere that completes the circuit. What is the measured voltage?<sup>201</sup>
- A.  $7.76 \times 10^4$  volts.  
 B.  $9.4 \times 10^4$  volts.  
 C.  $1.14 \times 10^5$  volts.  
**D.  $1.38 \times 10^5$  volts.**

The next page might contain more answer choices for this question

E.  $1.67 \times 10^5$  volts.

2. An loop of wire with 25 turns has a radius of 0.85 meters, and is oriented with its axis parallel to a magnetic field of 0.58 Tesla. What is the induced voltage if this field is reduced to 49

A.  $9.24 \times 10^0$  volts

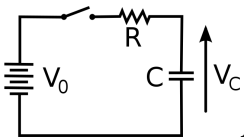
**B.  $1.12 \times 10^1$  volts**

C.  $1.36 \times 10^1$  volts

D.  $1.64 \times 10^1$  volts

E.  $1.99 \times 10^1$  volts

## 29 d\_cp2.16



1. A parallel plate capacitor with a capacitance  $C=1.00\text{E-}06$  F whose plates have an area  $A=225.9$  m<sup>2</sup> and separation  $d=2.00\text{E-}03$  m is connected via a switch to a  $2\ \Omega$  resistor and a battery of voltage  $V_0=2$  V as shown in the figure. The current starts to flow at time  $t=0$  when the switch is closed. What is the voltage at time  $t=4.00\text{E-}06$ ?<sup>202</sup>

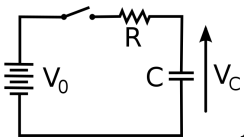
**A.  $1.729\text{E+}00$  V**

B.  $1.902\text{E+}00$  V

C.  $2.092\text{E+}00$  V

D.  $2.302\text{E+}00$  V

E.  $2.532\text{E+}00$  V



2. A parallel plate capacitor with a capacitance  $C=1.00\text{E-}06$  F whose plates have an area  $A=225.9$  m<sup>2</sup> and separation  $d=2.00\text{E-}03$  m is connected via a switch to a  $2\ \Omega$  resistor and a battery of voltage  $V_0=2$  V as shown in the figure. The current starts to flow at time  $t=0$  when the switch is closed. What is the magnitude of the electric field at time  $t=4.00\text{E-}06$ ?<sup>203</sup>

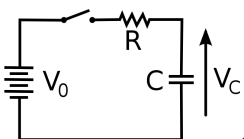
**A.  $8.647\text{E+}02$  V/m**

B.  $9.511\text{E+}02$  V/m

C.  $1.046\text{E+}03$  V/m

D.  $1.151\text{E+}03$  V/m

E.  $1.266\text{E+}03$  V/m



3. A parallel plate capacitor with a capacitance  $C=1.00\text{E-}06$  F whose plates have an area  $A=225.9$  m<sup>2</sup> and separation  $d=2.00\text{E-}03$  m is connected via a switch to a  $2\ \Omega$  resistor and a battery of voltage  $V_0=2$  V as shown in the figure. The current starts to flow at time  $t=0$  when the switch is closed. What is the magnitude of the displacement current at time  $t=4.00\text{E-}06$ ?<sup>204</sup>

A.  $1.230\text{E-}01$  A

The next page might contain more answer choices for this question

- B. 1.353E-01 A**  
C. 1.489E-01 A  
D. 1.638E-01 A  
E. 1.801E-01 A
4. A 60 kW radio transmitter on Earth sends its signal to a satellite 100 km away. At what distance in the same direction would the signal have the same maximum field strength if the transmitter's output power were increased to 90 kW?<sup>205</sup>
- A. 9.202E+01 km  
B. 1.012E+02 km  
C. 1.113E+02 km  
**D. 1.225E+02 km**  
E. 1.347E+02 km
5. What is the radiation pressure on an object that is 9.00E+10 m away from the sun and has cross-sectional area of 0.04 m<sup>2</sup>? The average power output of the Sun is 3.80E+26 W.<sup>206</sup>
- A. 1.701E-05 N/m<sup>2</sup>  
B. 1.871E-05 N/m<sup>2</sup>  
C. 2.058E-05 N/m<sup>2</sup>  
D. 2.264E-05 N/m<sup>2</sup>  
**E. 2.491E-05 N/m<sup>2</sup>**
6. What is the radiation force on an object that is 9.00E+10 m away from the sun and has cross-sectional area of 0.04 m<sup>2</sup>? The average power output of the Sun is 3.80E+26 W.<sup>207</sup>
- A. 8.233E-07 N  
B. 9.056E-07 N  
**C. 9.962E-07 N**  
D. 1.096E-06 N  
E. 1.205E-06 N

### 30 c24ElectromagneticWaves\_displacementCurrent

1. A circular capacitor of radius 4.2 m has a gap of 8 mm, and a charge of 45  $\mu$  C. What is the electric field between the plates?<sup>208</sup>
- A. 5.16E+04 N/C (or V/m)  
B. 6.25E+04 N/C (or V/m)  
C. 7.57E+04 N/C (or V/m)  
**D. 9.17E+04 N/C (or V/m)**  
E. 1.11E+05 N/C (or V/m)
2. A circular capacitor of radius 3.2 m has a gap of 13 mm, and a charge of 49  $\mu$  C. Compute the surface integral  $c^{-2} \oint \vec{E} \cdot d\vec{A}$  over an inner face of the capacitor.<sup>209</sup>
- A. 3.46E-11 Vs<sup>2</sup>m<sup>-1</sup>  
B. 4.20E-11 Vs<sup>2</sup>m<sup>-1</sup>

The next page might contain more answer choices for this question

- C.  $5.08\text{E-}11 \text{ Vs}^2\text{m}^{-1}$   
**D.  $6.16\text{E-}11 \text{ Vs}^2\text{m}^{-1}$**   
 E.  $7.46\text{E-}11 \text{ Vs}^2\text{m}^{-1}$

3. A circular capacitor of radius 4.9 m has a gap of 17 mm, and a charge of  $54 \mu\text{ C}$ . The capacitor is discharged through a  $9 \text{ k}\Omega$  resistor. What is the decay time? <sup>210</sup>

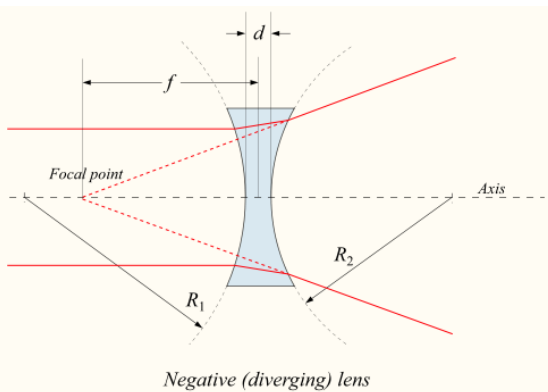
- A.  $2.92\text{E-}04 \text{ s}$   
**B.  $3.54\text{E-}04 \text{ s}$**   
 C.  $4.28\text{E-}04 \text{ s}$   
 D.  $5.19\text{E-}04 \text{ s}$   
 E.  $6.29\text{E-}04 \text{ s}$

4. A circular capacitor of radius 3.3 m has a gap of 12 mm, and a charge of  $93 \mu\text{ C}$ . The capacitor is discharged through a  $9 \text{ k}\Omega$  resistor. What is what is the maximum magnetic field at the edge of the capacitor? (There are two ways to do this; you should know both.)<sup>211</sup>

- A.  $9.88\text{E-}09 \text{ Tesla}$   
 B.  $1.24\text{E-}08 \text{ Tesla}$   
 C.  $1.57\text{E-}08 \text{ Tesla}$   
 D.  $1.97\text{E-}08 \text{ Tesla}$   
**E.  $2.48\text{E-}08 \text{ Tesla}$**

### 31 a25GeometricOptics\_image

1. figure:

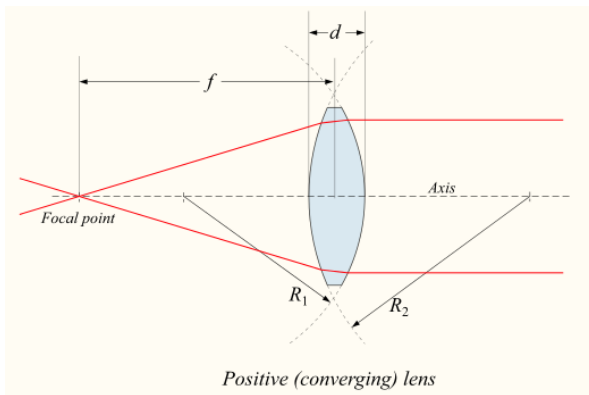


Shown is a corrective lens by a person who needs glasses. This ray diagram illustrates<sup>212</sup>

- A. how a nearsighted person might see a distant object**  
 B. how a nearsighted person might see an object that is too close for comfort  
 C. how a farsighted person might see an object that is too close for comfort  
 D. how a farsighted person might see a distant object

2. figure:

The next page might contain more answer choices for this question



Shown is a corrective lens by a person who needs glasses. This ray diagram illustrates<sup>213</sup>

- A. how a nearsighted person might see a distant object
  - B. how a farsighted person might see a distant object
  - C. how a farsighted person might see an object that is too close for comfort**
  - D. how a nearsighted person might see an object that is too close for comfort
3. In optics, "normal" means<sup>214</sup>
- A. to the left of the optical axis
  - B. parallel to the surface
  - C. perpendicular to the surface**
  - D. to the right of the optical axis
4. The law of reflection applies to<sup>215</sup>
- A. only light in a vacuum
  - B. telescopes but not microscopes
  - C. curved surfaces
  - D. both flat and curved surfaces**
  - E. flat surfaces
5. When light passes from air to glass<sup>216</sup>
- A. the frequency decreases
  - B. the frequency increases
  - C. it bends away from the normal
  - D. it bends towards the normal**
  - E. it does not bend
6. When light passes from glass to air<sup>217</sup>
- A. it does not bend
  - B. the frequency decreases
  - C. the frequency increases
  - D. it bends towards the normal
  - E. it bends away from the normal**
7. An important principle that allows fiber optics to work is<sup>218</sup>

The next page might contain more answer choices for this question

- A. the invariance of the speed of light
  - B. total internal reflection**
  - C. total external refraction
  - D. partial internal absorption
  - E. the Doppler shift
8. The focal point is where<sup>219</sup>
- A. rays meet whenever they pass through a lens
  - B. rays meet if they were parallel to the optical axis before striking a lens**
  - C. rays meet whenever they are forming an image
  - D. rays meet if they are parallel to each other
  - E. the center of the lens

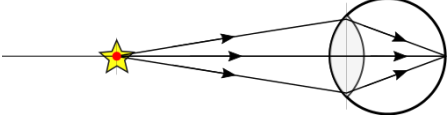
## 32 a25GeometricOptics\_thinLenses

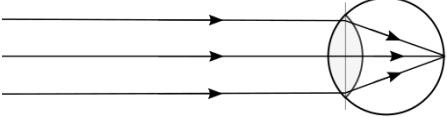
1. An object is placed 5.8 cm to the left of a diverging lens with a focal length of 4.9 cm. How far is the image from the lens?<sup>220</sup>
- A.  $4.72 \times 10^{-1}$  cm
  - B.  $8.4 \times 10^{-1}$  cm
  - C.  $1.49 \times 10^0$  cm
  - D.  $2.66 \times 10^0$  cm**
  - E.  $4.72 \times 10^0$  cm
2. An object is placed 6.05 cm to the left of a converging lens with a focal length of 5.4 cm. How far is the image from the lens?<sup>221</sup>
- A.  $5.03 \times 10^1$  cm**
  - B.  $8.94 \times 10^1$  cm
  - C.  $1.59 \times 10^2$  cm
  - D.  $2.83 \times 10^2$  cm
  - E.  $5.03 \times 10^2$  cm
3. An object of height 0.59 cm is placed 149 cm behind a diverging lens with a focal length of 57 cm. What is the height of the image?<sup>222</sup>
- A.  $1.63 \times 10^{-1}$  cm**
  - B.  $1.96 \times 10^{-1}$  cm
  - C.  $2.35 \times 10^{-1}$  cm
  - D.  $2.82 \times 10^{-1}$  cm
  - E.  $3.39 \times 10^{-1}$  cm
4. An object is placed 12.1 cm to the left of a diverging lens with a focal length of 15.4 cm. On the side, at a distance of 6.5 cm from the diverging lens is a converging lens with focal length equal to 4 cm. How far is the final image from the converging lens?<sup>16.65</sup><sup>223</sup>
- A.  $5.72 \times 10^0$  cm**
  - B.  $1.81 \times 10^1$  cm
  - C.  $5.72 \times 10^1$  cm
  - D.  $1.81 \times 10^2$  cm
  - E.  $5.72 \times 10^2$  cm

The next page might contain more answer choices for this question

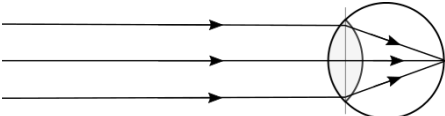
### 33 a25GeometricOptics\_vision

1. Which lens has the shorter focal length?<sup>224</sup>

A.  **The lens shown above-left.**

B.  **The lens shown above-left.**

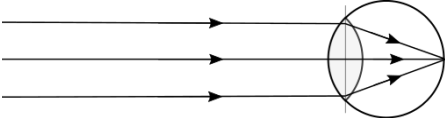
C. Both lenses have the same the same focal length

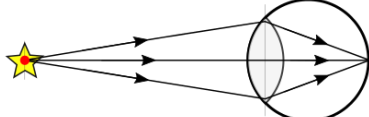
2.  Refer to the figure to the left and above: If this represents the eye looking at an object, where is this object?<sup>225</sup>

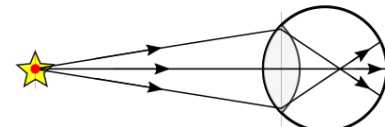
- A. One focal length in front of the eye
- B. Very far away**
- C. One focal length behind the eye
- D. at the eye's cornea
- E. at eye's retina

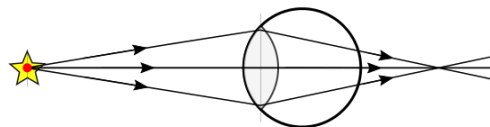
3. The focal point is where the rays from an object meet after they have passed through a lens.<sup>226</sup>

- A. False**
- B. True

4.  Mr. Smith is gazing at something in the figure shown above and to the left. Suppose the object is suddenly moved closer, but for some reason Mr. Smith does not refocus his eyes. Which drawing below best depicts the rays' paths.<sup>227</sup>

A.  **The drawing shown above-left**

B.  **The drawing shown above-left**

C.  **The drawing shown above-left**

The next page might contain more answer choices for this question



### 34 d\_Bell.photon

1. If the wavelength " $\lambda$ " associated with a photon is cut in half, the photon's energy " $E$ "<sup>228</sup>
  - A. is cut in half
  - B. is reduced by a factor of 4
  - C. stays the same
  - D. becomes twice as big**
  - E. becomes 4 times as big
2. If the wavelength " $\lambda$ " associated with a photon doubles, the photon's frequency " $f$ "<sup>229</sup>
  - A. is cut in half**
  - B. is reduced by a factor of 4
  - C. stays the same
  - D. becomes twice as big
  - E. becomes 4 times as big
3. If the frequency " $f$ " associated with a photon increases by a factor of 4, the photon's wavelength " $\lambda$ "<sup>230</sup>
  - A. is cut in half
  - B. is reduced by a factor of 4**
  - C. stays the same
  - D. becomes twice as big
  - E. becomes 4 times as big
4. If the frequency " $f$ " associated with a photon increases by a factor of 4, the photon's energy " $E$ "<sup>231</sup>
  - A. is cut in half
  - B. is reduced by a factor of 4
  - C. stays the same
  - D. becomes twice as big
  - E. becomes 4 times as big**
5. If an atom emits two photons in a cascade emission and both photons have 2 eV of energy, the atom's energy<sup>232</sup>
  - A. stays the same
  - B. increases by 2 eV
  - C. increases by 4 eV
  - D. decreases by 2 eV
  - E. decreases by 4 eV**
6. If an atom absorbs a photon with 2 eV energy, the atom's energy<sup>233</sup>
  - A. stays the same
  - B. increases by 2 eV**
  - C. increases by 4 eV
  - D. decreases by 2 eV
  - E. decreases by 4 eV

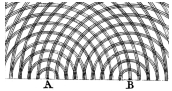
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7. If a 3 eV photon strikes a metal plate and causes an electron to escape, that electron will have a kinetic energy that is<sup>234</sup>
- A. zero
  - B. less than 3 eV**
  - C. equal to 3 eV
  - D. greater than 3 eV
  - E. equal to 6 eV
8. In the PhET Interactive Simulation for photoelectric effect, how was the electron's kinetic energy measured?<sup>235</sup>
- A. measuring spin
  - B. measuring polarization
  - C. measuring both spin and polarization
  - D. deflecting the electron with a magnetic field
  - E. stopping the electron with an applied voltage**
9. If an atom absorbs a photon with 4 eV energy, the atom's energy<sup>236</sup>
- A. stays the same
  - B. increases by 2 eV
  - C. increases by 4 eV
  - D. decreases by 2 eV
  - E. decreases by 4 eV**
10. If  $10^{18}$  photons pass through a small hole in your roof every second, how many photons would pass through it if you doubled the diameter?<sup>237</sup>
- A.  $10^{18}$
  - B.  $2 \times 10^{18}$
  - C.  $4 \times 10^{18}$**
  - D.  $6 \times 10^{18}$
  - E.  $8 \times 10^{18}$
11. Two black bodies are created by cutting identical small holes in two large containers. The holes are oriented so that all the photons leaving one will enter the other. The objects have different temperature and different volume. Which object has the greater electromagnetic ("photon") energy density (energy per unit volume)?<sup>238</sup>
- A. The hotter object has a greater energy density.**
  - B. The larger object has a greater energy density.
  - C. They have the same energy density (since the holes are identical).
  - D. No unique answer exists because two variables are involved (temperature and volume).
12. Two black bodies are created by cutting identical small holes in two large containers. The holes are oriented so that all the photons leaving one will enter the other. The objects have different temperature and different volume. Which object emits more photons per second (above a given threshold energy)?<sup>239</sup>
- A. The object with the greater temperature emits more.**
  - B. The object with the greater volume.
  - C. They both emit the same number of photons (since the holes are identical).

The next page might contain more answer choices for this question

D. No unique answer exists because two variables are involved (temperature and volume).

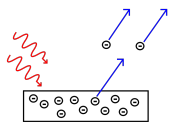
13. Two black bodies of are created by cutting identical small holes in two large containers. The holes are oriented so that all the photons leaving one will enter the other. The objects have different temperature and different volume. Which object has the greater electromagnetic ("photon") energy?<sup>240</sup>
- The hotter object has a greater energy.
  - The larger object has a greater energy.
  - They have the same energy (since the holes are identical).
  - No unique answer exists because two variables are involved (temperature and volume).**



14. This figure is associated with <sup>241</sup>
- Photons striking metal and ejecting electrons (photo-electric effect explained in 1905)
  - Diffraction observed in light so faint that photons seemed to have no mechanism to interact with each other
  - A system similar to the one that led to the 1901 proposal that light energy is quantized as integral multiples of  $hf$  (except that Plank assumed that the walls were conductive.)
  - Evidence presented in 1800 that light is a wave.**
  - The transfer of energy and momentum of a high energy photon of a nearly free electron.

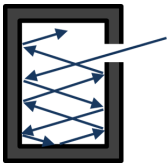


15. This figure is associated with <sup>242</sup>
- Photons striking metal and ejecting electrons (photo-electric effect explained in 1905)
  - Diffraction observed in light so faint that photons seemed to have no mechanism to interact with each other**
  - A system similar to the one that led to the 1901 proposal that light energy is quantized as integral multiples of  $hf$  (except that Plank assumed that the walls were conductive.)
  - Evidence presented in 1800 that light is a wave.
  - The transfer of energy and momentum of a high energy photon of a nearly free electron.



16. This figure is associated with <sup>243</sup>
- Photons striking metal and ejecting electrons (photo-electric effect explained in 1905)**
  - Diffraction observed in light so faint that photons seemed to have no mechanism to interact with each other
  - A system similar to the one that led to the 1901 proposal that light energy is quantized as integral multiples of  $hf$  (except that Plank assumed that the walls were conductive.)
  - Evidence presented in 1800 that light is a wave.
  - The transfer of energy and momentum of a high energy photon of a nearly free electron.

The next page might contain more answer choices for this question



17. This figure is associated with <sup>244</sup>
- Photons striking metal and ejecting electrons (photo-electric effect explained in 1905)
  - Diffraction observed in light so faint that photons seemed to have no mechanism to interact with each other
  - A system similar to the one that led to the 1901 proposal that light energy is quantized as integral multiples of  $hf$**
  - Evidence presented in 1800 that light is a wave.
  - The transfer of energy and momentum of a high energy photon of a nearly free electron.
18. A photon is polarized at  $5^\circ$  when it encounters a filter oriented at  $35^\circ$ . What is the probability that it passes?<sup>245</sup>
- 0
  - 1/4
  - 1/2
  - 3/4**
  - 1
19. A photon is polarized at  $10^\circ$  when it encounters a filter oriented at  $55^\circ$ . What is the probability that it passes?<sup>246</sup>
- 0
  - 1/4
  - 1/2**
  - 3/4
  - 1
20. A photon is polarized at  $10^\circ$  when it encounters a filter oriented at  $70^\circ$ . What is the probability that it passes?<sup>247</sup>
- 0
  - 1/4**
  - 1/2
  - 3/4
  - 1
21. A photon is polarized at  $10^\circ$  when it encounters a filter oriented at  $40^\circ$ . What is the probability that it is blocked?<sup>248</sup>
- 0
  - 1/4
  - 1/2
  - 3/4**
  - 1
22. A photon is polarized at  $5^\circ$  when it encounters a filter oriented at  $50^\circ$ . What is the probability that it is blocked?<sup>249</sup>
- 0

The next page might contain more answer choices for this question

- B.  $1/4$
- C.  $1/2$**
- D.  $3/4$
- E. 1

23. A photon is polarized at  $5^\circ$  when it encounters a filter oriented at  $65^\circ$ . What is the probability that it is blocked?<sup>250</sup>

- A. 0
- B.  $1/4$**
- C.  $1/2$
- D.  $3/4$
- E. 1

24. A photon is polarized at  $10^\circ$  when it encounters a filter oriented at  $100^\circ$ . What is the probability that it passes?<sup>251</sup>

- A. 0**
- B.  $1/4$
- C.  $1/2$
- D.  $3/4$
- E. 1

25. A photon is polarized at  $10^\circ$  when it encounters a filter oriented at  $100^\circ$ . What is the probability that it is blocked?<sup>252</sup>

- A. 0
- B.  $1/4$
- C.  $1/2$
- D.  $3/4$
- E. 1**

### 35 d\_Bell.polarization

1. The light is linearly polarized, the electric field is oriented \_\_\_\_\_ to the direction of motion<sup>253</sup>

- A. parallel
- B. perpendicular**
- C. at 45 degrees
- D. all of these are possible

2. Hold a pendulum a moderate distance from equilibrium and release it by tossing it in a direction perpendicular to the displacement of the mass from equilibrium. The resulting polarization will be \_\_\_\_\_ (pick the best answer)<sup>254</sup>

- A. linear
- B. circular
- C. circular or linear
- D. circular or elliptical**
- E. linear or elliptical

The next page might contain more answer choices for this question

3. A mathematically pure (monochromatic) \_\_\_\_\_ wave or oscillation that is unpolarized cannot be created if it is<sup>255</sup>
- A. electromagnetic
  - B. a pendulum
  - C. either electromagnetic or a pendulum**
  - D. both oscillations can be created as pure (monochromatic) oscillations
4. To create an unpolarized pendulum oscillation<sup>256</sup>
- A. create an elliptically polarized wave with an  $\epsilon_i 0.2$
  - B. create an elliptically polarized wave with an  $\epsilon_i 0.8$
  - C. create an elliptically polarized wave with an  $0.2; \epsilon_i 0.8$
  - D. start with a linear, circular, or elliptical wave and evolve it randomly to different polarizations**
5. If the hypotenuse of a  $45^\circ$ - $45^\circ$  right triangle has a length of  $\sqrt{2}$  what is the length of each side?<sup>257</sup>
- A.  $\frac{1}{2}$
  - B.  $\frac{1}{\sqrt{2}}$
  - C. 1
  - D.  $\sqrt{2}$**
  - E.  $2\sqrt{2}$
6. If the hypotenuse of a  $45^\circ$ - $45^\circ$  right triangle has a length of 1 what is the length of each side?<sup>258</sup>
- A.  $\frac{1}{2}$
  - B.  $\frac{1}{\sqrt{2}}$**
  - C. 1
  - D.  $\sqrt{2}$
  - E.  $2\sqrt{2}$
7. If the hypotenuse of a  $60^\circ$ - $30^\circ$  right triangle has a length of 1 what is the length of the shorter side?<sup>259</sup>
- A.  $\frac{1}{4}$
  - B.  $\frac{1}{\sqrt{2}}$
  - C.  $\frac{1}{2}$
  - D.  $\frac{\sqrt{3}}{2}$
  - E.  $\frac{3}{4}$
8. If the hypotenuse of a  $60^\circ$ - $30^\circ$  right triangle has a length of 1 what is the length of the longer side?<sup>260</sup>
- A.  $\frac{1}{4}$
  - B.  $\frac{1}{\sqrt{2}}$
  - C.  $\frac{1}{2}$
  - D.  $\frac{\sqrt{3}}{2}$**
  - E.  $\frac{3}{4}$

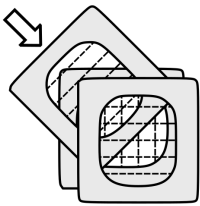
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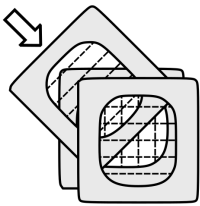
9. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. By what factor does a filter reduce the electric field if it is oriented  $30^\circ$  to that field?<sup>261</sup>
- A.  $\frac{1}{4}$
  - B.  $\frac{1}{\sqrt{2}}$
  - C.  $\frac{1}{2}$
  - D.  $\frac{\sqrt{3}}{2}$**
  - E.  $\frac{3}{4}$
10. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. By what factor does a filter reduce the electric field if it is oriented  $60^\circ$  to that field?<sup>262</sup>
- A.  $\frac{1}{4}$
  - B.  $\frac{1}{\sqrt{2}}$
  - C.  $\frac{1}{2}$
  - D.  $\frac{\sqrt{3}}{2}$
  - E.  $\frac{3}{4}$
11. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. A 12 mW laser strikes a polarizing filter oriented  $30^\circ$  to the incoming axis of polarization. How much power passes the filter?<sup>263</sup>
- A. 3mW
  - B. 4mW
  - C. 6mW
  - D. 8mW
  - E. 9mW**
12. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. A 12 mW laser strikes a polarizing filter oriented  $30^\circ$  to the incoming axis of polarization. How much power is blocked by the filter?<sup>264</sup>
- A. 3mW**
  - B. 4mW
  - C. 6mW
  - D. 8mW
  - E. 9mW
13. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. A 12 mW laser strikes a polarizing filter oriented  $60^\circ$  to the incoming axis of polarization. How much power is blocked by the filter?<sup>265</sup>
- A. 3mW
  - B. 4mW
  - C. 6mW
  - D. 8mW

The next page might contain more answer choices for this question

**E. 9mW**

14. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. A 12 mW laser strikes a polarizing filter oriented  $60^\circ$  to the incoming axis of polarization. How much power is passed by the filter?<sup>266</sup>
- A. 3mW**  
 B. 4mW  
 C. 6mW  
 D. 8mW  
 E. 9mW
15. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. A 12 mW laser strikes a polarizing filter oriented  $45^\circ$  to the incoming axis of polarization. How much power is passed by the filter?<sup>267</sup>
- A. 3mW  
 B. 4mW  
**C. 6mW**  
 D. 8mW  
 E. 9mW



16.  A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. Unpolarized light impinges on three linear filters, each oriented  $45^\circ$  to the previous, as shown. What fraction of the power incident on the first filter emerges from the last?<sup>268</sup>
- A.  $1/32$   
 B.  $1/16$   
 C.  $3/32$   
**D.  $1/8$**   
 E.  $3/16$
17. Hold a pendulum a moderate distance from equilibrium and release it by tossing it in a direction parallel to the displacement of the mass from equilibrium. The resulting polarization will be ----- (pick the best answer)<sup>269</sup>
- A. linearly**  
 B. circular  
 C. circular or linear  
 D. circular or elliptical  
 E. linear or elliptical
18. A linear polarizer selects a component of the electric field. Also, the energy density of light is proportional to the square of the electric field. Unpolarized light impinges on three linear filters. The second is oriented  $30^\circ$  from the first, and the third is rotated by an additional  $60^\circ$ , making it at right angles from the first filter. What fraction of the power incident on the first filter emerges from the last?<sup>270</sup>

The next page might contain more answer choices for this question



- A. 1/32
- B. 1/16
- C. 3/32**
- D. 1/8
- E. 3/16

### 36 b\_QuantumTimeline

1. Excepting cases where where quantum jumps in energy are induced in another object (i.e., using only the uncertainty principle), which would NOT put a classical particle into the quantum regime?<sup>271</sup>
  - A. high speed**
  - B. confinement to a small space
  - C. low speed
  - D. low mass
2. How does the Bohr atom differ from Newton's theory of planetary orbits?<sup>272</sup>
  - A. The force between proton and electron is not attractive for the atom, but it is for planets and the sun.
  - B. The force between planets and the sun is not attractive for the atom, but it is for proton and electron.
  - C. planets make elliptical orbits while the electron makes circular orbits**
  - D. electrons make elliptical orbits while planets make circular orbits
3. What are the units of Plank's constant?<sup>273</sup>
  - A. mass x velocity x distance
  - B. energy x time
  - C. momentum x distance
  - D. all of the above**
  - E. none of the above
4. What are the units of Plank's constant?<sup>274</sup>
  - A. mass x energy
  - B. energy x distance
  - C. momentum x time x mass
  - D. all of the above
  - E. none of the above**
5. How would you describe Old Quantum Theory?<sup>275</sup>
  - A. complete and self-consistent
  - B. complete but not self-consistent
  - C. self-consistent but not complete
  - D. neither complete nor self-consistent**
6. The first paper that introduced quantum mechanics was Plank's study of <sup>276</sup>
  - A. light**

The next page might contain more answer choices for this question

- B. electrons
  - C. protons
  - D. energy
7. What are examples of energy?<sup>277</sup>
- A.  $\frac{1}{2}mv^2$
  - B. mgh where m is mass, g is gravity, and h is height
  - C. heat
  - D. all of the above**
  - E. none of the above
8. What are examples of energy?<sup>278</sup>
- A.  $\frac{m}{v}$
  - B. force
  - C. mg where m is mass, g is gravity, and h is height
  - D. all of the above
  - E. none of the above**
9. What was Plank's understanding of the significance of his work on blackbody radiation?<sup>279</sup>
- A. he was afraid to publish it for fear of losing his reputation
  - B. he eventually convinced his dissertation committee that the theory was correct
  - C. the thought it was some sort of mathematical trick**
  - D. he knew it would someday win him a Nobel prize
10. What was "spooky" about Taylor's 1909 experiment with wave interference?<sup>280</sup>
- A. The light was so dim that the photoelectric effect couldn't occur
  - B. The light was dim, but it didn't matter because he was blind.
  - C. The light was so dim that only one photon at a time was near the slits.**
  - D. The interference pattern mysteriously disappeared.
11. The pilot wave hypothesis was that the Schroedinger wave described the electron's charge density.<sup>281</sup>
- A. True
  - B. False**
12. The pilot wave hypothesis was that the Schroedinger wave described the electron's probability density.<sup>282</sup>
- A. True
  - B. False**
13. The pilot wave hypothesis was that the Schroedinger wave described a force on the electron.<sup>283</sup>
- A. True
  - B. False**

The next page might contain more answer choices for this question

### 37 b\_WhyIsSkyDarkAtNight

1. Approximately how often does a supernovae occur in a typical galaxy?<sup>284</sup>
  - A. once a 5 months
  - B. once every 5 years
  - C. once every 50 years**
2. If a star were rushing towards Earth at a high speed<sup>285</sup>
  - A. there would be a blue shift in the spectral lines**
  - B. there would be a red shift in the spectral lines
  - C. there would be no shift in the spectral lines
3. An example of a standard candle is<sup>286</sup>
  - A. any part of the nighttime sky that is giving off light
  - B. any part of the nighttime sky that is dark
  - C. a supernova in a distant galaxy**
  - D. all of these are standard candles
4. If a galaxy that is 10 Mpc away is receding at 700km/s, how far would a galaxy be receding if it were 20 Mpc away?<sup>287</sup>
  - A. 350km/s
  - B. 700km/s
  - C. 1400km/s**
5. The "apparent" magnitude of a star is<sup>288</sup>
  - A. How bright it would be if you were exactly one light year away
  - B. How bright it would be if it were not receding due to Hubble expansion
  - C. How bright it is as viewed from Earth**
6. In the essay "Why the sky is dark at night", a graph of velocity versus distance is shown. What is odd about those galaxies in the Virgo cluster (circled in the graph)?<sup>289</sup>
  - A. they all have nearly the same speed
  - B. they have a wide variety of speeds**
  - C. they are not receding away from us
  - D. the cluster is close to us
7. Why was it important to observe supernovae in galaxies that are close to us?<sup>290</sup>
  - A. we have other ways of knowing the distances to the nearby galaxies; this gives us the opportunity to study supernovae of known distance and ascertain their absolute magnitude.**
  - B. they have less of a red-shift, and interstellar gas absorbs red light
  - C. it is easier to measure the doppler shift, and that is not always easy to measure.
  - D. because supernovae are impossible to see in distant galaxies
8. What if clouds of dust blocked the light from distant stars? Could that allow for an infinite and static universe?<sup>291</sup>
  - A. No, the clouds would get hot**
  - B. No, if there were clouds, we wouldn't see the distant galaxies
  - C. No, there are clouds, but they remain too cold to resolve the paradox
  - D. Yes, that is an actively pursued hypothesis

The next page might contain more answer choices for this question

### 38 d\_Bell.binomial

1. The normal distribution (often called a "bell curve") is never skewed<sup>292</sup>
  - A. **True**
  - B. False
2. The normal distribution (often called a "bell curve") is usually skewed<sup>293</sup>
  - A. True
  - B. **False**
3. By definition, a skewed distribution<sup>294</sup>
  - A. is broader than an unskewed distribution
  - B. includes negative values of the observed variable
  - C. is a "normal" distribution
  - D. **is asymmetric about its peak value**
  - E. contains no outliers
4. The binomial distribution results from observing n outcomes, each having a probability p of "success"<sup>295</sup>
  - A. **True**
  - B. False
5. What is the probability of success, p, for a binary distribution using a six-sided die, with success defined as "two"?<sup>296</sup>
  - A. 3/6
  - B. 2/6
  - C. **1/6**
  - D. 5/6
  - E. 4/6
6. What is the probability of success, p, for a binary distribution using a six-sided die, with success defined as anything but "two"?<sup>297</sup>
  - A. 3/6
  - B. 2/6
  - C. 1/6
  - D. **5/6**
  - E. 4/6
7. What is the probability of success, p, for a binary distribution using a six-sided die, with success defined as either a "two" or a "three"?<sup>298</sup>
  - A. 3/6
  - B. **2/6**
  - C. 1/6
  - D. 5/6
  - E. 4/6

The next page might contain more answer choices for this question

8. How would you describe the "skew" of a binary distribution?<sup>299</sup>
- A. The binary distribution is always skewed, but has little skew for a large number of trials  $n$ .**
  - B. The binary distribution is always skewed, but has little skew for a small number of trials  $n$ .
  - C. The binary distribution is never skewed if it is a true binary distribution.
  - D. Distributions are never skewed. Only experimental measurements of them are skewed.
  - E. None of these are true.
9. For a binomial distribution with  $n$  trials, the variance is  $\sigma^2=np(1-p)$ . If 90 trials are observed, then 68% of the time the observed number of positive outcomes will fall within  $\pm$ \_\_\_ of the expected value if  $p=.11$  is the probability of a positive outcome. Make the approximation that this binomial distribution is approximately a Gaussian (normal) distribution.<sup>300</sup>
- A. 6
  - B. 18
  - C. 3**
  - D. 9
  - E. 1
10. For a binomial distribution with  $n$  trials, the variance is  $\sigma^2=np(1-p)$ . If 40 trials are observed, then 68% of the time the observed number of positive outcomes will fall within  $\pm$ \_\_\_ of the expected value if  $p=.11$  is the probability of a positive outcome. Make the approximation that this binomial distribution is approximately a Gaussian (normal) distribution.<sup>301</sup>
- A. 6
  - B. 18
  - C. 3
  - D. 9
  - E. 2**
11. For a binomial distribution with  $n$  trials, the variance is  $\sigma^2=np(1-p)$ . If 40 trials are made and  $p=.11$ , the expected number of positive outcomes is\_\_\_. Make the approximation that this binomial distribution is approximately a Gaussian (normal) distribution.<sup>302</sup>
- A. 4.4**
  - B. 2.2
  - C. 9.9
  - D. 3.3
  - E. 1.1
12. For a binomial distribution with  $n$  trials, the variance is  $\sigma^2=np(1-p)$ . If 90 trials are made and  $p=.11$ , the expected number of positive outcomes is\_\_\_. Make the approximation that this binomial distribution is approximately a Gaussian (normal) distribution.<sup>303</sup>
- A. 2.2
  - B. 9.9**
  - C. 3.3
  - D. 1.1

The next page might contain more answer choices for this question

13. Recall that only 4.6% of the outcomes for a normal distribution lie outside of two standard deviations from the mean, and approximate the binomial distribution as normal for large numbers. If the variance is  $\sigma^2 = np(1-p)$  where  $n$  is the number of trials and  $p = .11$  is the probability of a positive outcome for 40 trials, roughly 98% of the outcomes will be smaller than approximately \_\_<sup>304</sup>
- A. 6
  - B. 8**
  - C. 12
  - D. 16
  - E. 22
14. Recall that only 4.6% of the outcomes for a normal distribution lie outside of two standard deviations from the mean, and approximate the binomial distribution as normal for large numbers. If the variance is  $\sigma^2 = np(1-p)$  where  $n$  is the number of trials and  $p = .11$  is the probability of a positive outcome for 90 trials, roughly 98% of the outcomes will be smaller than approximately \_\_<sup>305</sup>
- A. 6
  - B. 8
  - C. 12
  - D. 16**
  - E. 22
15. A local college averages 2500 new incoming students each year. Suppose the pool of potential high school graduates in the local area is so large that the probability of a given student selecting this college is small, and assume a variance of  $\sigma^2$  equal to  $p(1-p)$ . What standard deviation would you expect in the yearly total of new enrollees, assuming nothing changes in this population from year to year? <sup>306</sup>
- A. 50**
  - B. 150
  - C. 500
  - D. 200
  - E. 250
16. A local college averages 1600 new incoming students each year. Suppose the pool of potential high school graduates in the local area is so large that the probability of a given student selecting this college is small, and assume a variance of  $\sigma^2$  equal to  $p(1-p)$ . What standard deviation would you expect in the yearly total of new enrollees, assuming nothing changes in this population from year to year? <sup>307</sup>
- A. 16
  - B. 160
  - C. 40**
  - D. 10
  - E. 32

### 39 d\_Bell.partners

1. When is the referee allowed to observe Alice and Bob?<sup>308</sup>
  - A. never

The next page might contain more answer choices for this question

- B. While they are discussing strategy (phase 1), but not while their backs are turned to each other.
- C. While their backs are turned, but not while they are discussing strategy (phase 1)**
- D. The referee should carefully observe Alice and Bob all the time
2. Is it cheating for one of the partners to change their mind in after communication ceases?<sup>309</sup>
- A. It is cheating and the game should be terminated if the partners are caught doing this
- B. It is cheating, but fortunately the penalty allows partners to do it
- C. It is not cheating, but allowing to partners to do so violates the spirit of the game as a Bell's test experiment simulation.
- D. It is not cheating, and allowing to partners to do this is in the spirit of the game as a Bell's test experiment simulation.**
3. The  $\beta$  -strategy is a new strategy introduced in the couples version of the card game that calls for<sup>310</sup>
- A. Alice and Bob to sometimes give different answers (one "even" while the other "odd")
- B. Alice and Bob to always give different answers (one "even" while the other "odd")**
- C. Alice and Bob to always answer "even"
- D. Alice and Bob to always answer "odd"
- E. None of these describes the  $\beta$  -strategy
4. The  $\alpha$  -strategy in the couples version of the card game is similar to the strategy introduced in the solitaire version, and calls for<sup>311</sup>
- A. Alice and Bob to sometimes give different answers (one "even" while the other "odd")
- B. Alice and Bob to always give different answers (one "even" while the other "odd")**
- C. Alice and Bob to always answer "even"
- D. Alice and Bob to always answer "odd"
- E. None of these describes the  $\alpha$  -strategy
5. Suppose the referee gives Alice and Bob receive question cards of the different suit (different questions). What are the best and worst possible outcomes for the partners? (Assume for this question that  $Q > 3$ )<sup>312</sup>
- A. Best for partners:  $+1$  ... Worst:  $-Q$
- B. Best for partners:  $+1$  ... Worst:  $-3$**
- C. Best for partners:  $0$  ... Worst:  $-Q$
- D. Best for partners:  $0$  ... Worst:  $-3$
- E. None of these is correct
6. Suppose the referee gives Alice and Bob receive question cards of the same suit (same questions). What are the best and worst possible outcomes for the partners? (Assume for this question that  $Q > 3$ )<sup>313</sup>
- A. Best for partners:  $+1$  ... Worst:  $-Q$
- B. Best for partners:  $+1$  ... Worst:  $-3$
- C. Best for partners:  $0$  ... Worst:  $-Q$**
- D. Best for partners:  $0$  ... Worst:  $-3$
- E. None of these is correct
7. Suppose the partners choose the  $\beta$  strategy (which was not available in the solitaire version). What are the best and worst possible outcomes for the partners? (Assume for this question that  $Q > 3$ )<sup>314</sup>

The next page might contain more answer choices for this question

- A. **Best for partners: +1 ... Worst:  $-Q$**   
 B. Best for partners: +1 ... Worst:  $-3$   
 C. Best for partners: 0 ... Worst:  $-Q$   
 D. Best for partners: 0 ... Worst:  $-3$   
 E. None of these is correct
8. Suppose both partners choose to answer "even" to any question that is asked. What are the best and worst possible outcomes for the partners? (Assume for this question that  $Q > 3$ )<sup>315</sup>
- A. **Best for partners: +1 ... Worst:  $-Q$**   
 B. Best for partners: +1 ... Worst:  $-3$   
 C. Best for partners: 0 ... Worst:  $-Q$   
 D. **Best for partners: 0 ... Worst:  $-3$**   
 E. None of these is correct
9. Suppose both partners choose to answer "even" to any question that is asked. Why would such a strategy ever be adopted? (Assume for this question that  $Q > 3$ )<sup>316</sup>
- A. The partners might have cheated so much in the past that they need to lose a round.  
 B. One partner might announce that all answers will be "even", while the other is certain that the both question cards will have the same suit.  
 C. Both partners agree that there is a 90  
 D. **Two of these reasons for this strategy might be valid**  
 E. There is no reason for the partners to ever adopt this strategy
10. How much do the partners win or lose if Alice answers  $4\spadesuit$  to  $K\spadesuit$  while Bob answers  $4\heartsuit$  to  $A\heartsuit$ ?<sup>317</sup>
- A. win 1 point  
 B. lose  $Q$  points  
 C. no points awarded or lost  
 D. **lose 3 points**
11. How much do the partners win or lose if Alice answers  $4\spadesuit$  to  $K\spadesuit$  while Bob answers  $5\heartsuit$  to  $A\heartsuit$ ?<sup>318</sup>
- A. **win 1 point**  
 B. lose  $Q$  points  
 C. no points awarded or lost  
 D. lose 3 points
12. How much do the partners win or lose if Alice answers  $4\spadesuit$  to  $K\spadesuit$  while Bob answers  $4\spadesuit$  to  $A\spadesuit$ ?<sup>319</sup>
- A. win 1 point  
 B. lose  $Q$  points  
 C. **no points awarded or lost**  
 D. lose 3 points
13. How much do the partners win or lose if Alice answers  $4\spadesuit$  to  $K\spadesuit$  while Bob answers  $5\spadesuit$  to  $A\spadesuit$ ?<sup>320</sup>
- A. win 1 point  
 B. **lose  $Q$  points**

The next page might contain more answer choices for this question



- C. no points awarded or lost  
D. lose 3 points
14. Suppose referee adopts neutral scoring with  $Q=4$  and asks the same question with a probability  $P_S=0.25$ . This reduces the average loss rate for their partners for the following reason: Consider a probability space with<sup>321</sup>
- A. 3 equally probable events: On two they are given different questions, winning twice. On the third event they are given the same answer and lose a point.  
B. 3 equally probable events: On two they are given different questions, winning once and losing once. On the third event they are given the same answer and lose a point.  
C. 3 equally probable events: On two they are given different questions, winning once and losing once. On the third event they are given the same answer and neither gain nor lose a point.  
D. 4 equally probable events: On three they are given different questions, winning once but losing twice. On the fourth event they are given the same answer and lose a point.  
**E. 4 equally probable events: On three they are given different questions, winning twice but losing once. On the fourth event they are given the same answer and neither gain nor lose a point.**
15. Although it decreases the rate at which the partners lose point, increasing the probability of asking the same question is more effective at persuading students to act as particles by relying on the  $\alpha$ -strategy because relying on a larger penalty for giving different answers to the same question will tempt students to use the  $\beta$ -strategy only briefly (hoping never to be caught) and then requesting a break to "re-establish" quantum entanglement.<sup>322</sup>
- A. True**  
B. False
16. Suppose the referee selects neutral scoring with  $Q = \frac{4}{3} \left( \frac{1-P_S}{P_S} \right)$ . What number does the penalty approach as the probability of asking the same question goes to 1?<sup>323</sup>
- A. 0  
B.  $\infty$   
C. 3  
D. 4  
E. 4/3
17. Suppose the referee selects neutral scoring with  $Q = \frac{4}{3} \left( \frac{1-P_S}{P_S} \right)$ . What number does the penalty approach as the probability of asking the same question goes to 0?<sup>324</sup>
- A. 0  
B.  $\infty$   
C. 3  
D. 4  
E. 4/3
18. Suppose the referee selects neutral scoring with  $Q = \frac{4}{3} \left( \frac{1-P_S}{P_S} \right)$ . What is the penalty if the probability of asking the same question is 0.25?<sup>325</sup>
- A. 0  
B.  $\infty$

The next page might contain more answer choices for this question

- C. 3
- D. 4**
- E. 4/3

19. Suppose the referee selects neutral scoring with  $Q = \frac{4}{3} \left( \frac{1-P_S}{P_S} \right)$ . What is the penalty if the probability of asking the same question is 0.5?<sup>326</sup>
- A. 0
  - B.  $\infty$
  - C. 3
  - D. 4
  - E. 4/3**

## 40 d\_Bell.solitaire

1. Your solitaire deck uses  $\heartsuit \spadesuit \clubsuit$  and your answer cards are 4 and 5. You select  $4\spadesuit, 4\clubsuit,$  and  $5\heartsuit$ . If the questions were  $Q\spadesuit$  and  $Q\clubsuit$ , you would\_\_\_<sup>327</sup>
- A. lose 3 points**
  - B. lose 1 point
  - C. win 1 point
  - D. win 3 points
  - E. be disqualified for cheating
2. Your solitaire deck uses  $\heartsuit \spadesuit \clubsuit$  and your answer cards are 4 and 5. You select  $4\spadesuit, 5\clubsuit,$  and  $5\heartsuit$ . If the questions were  $Q\spadesuit$  and  $Q\clubsuit$ , you would\_\_\_<sup>328</sup>
- A. lose 3 points
  - B. lose 1 point
  - C. win 1 point**
  - D. win 3 points
  - E. be disqualified for cheating
3. You solitaire deck uses  $\heartsuit \spadesuit \clubsuit$  and your answer cards are 4 and 5. You select  $4\spadesuit, 5\clubsuit,$  and  $5\heartsuit$ . If the questions were  $Q\spadesuit$  and  $Q\clubsuit$ . Which of the following wins?<sup>329</sup>
- A.  $K\heartsuit$  and  $K\spadesuit$
  - B.  $K\spadesuit$  and  $K\clubsuit$
  - C.  $K\heartsuit$  and  $K\clubsuit$
  - D. two of these are true**
  - E. none of these are true
4. You solitaire deck uses  $\heartsuit \spadesuit \clubsuit$  and your answer cards are 4 and 5. You select  $4\spadesuit, 5\clubsuit,$  and  $5\heartsuit$ . If the questions were  $Q\spadesuit$  and  $Q\clubsuit$ . Which of the following loses?<sup>330</sup>
- A.  $K\heartsuit$  and  $K\spadesuit$
  - B.  $K\spadesuit$  and  $K\clubsuit$
  - C.  $K\heartsuit$  and  $K\clubsuit$**

The next page might contain more answer choices for this question

- D. two of these are true
- E. none of these are true

5. If you play the solitaire game 6 times, you will on average win \_\_\_\_ times.<sup>331</sup>

- A. 4**
- B. 2
- C. 3
- D. 6
- E. 5

6. If you play the solitaire game 3 times, you will on average lose \_\_\_\_ times.<sup>332</sup>

- A. 1**
- B. 2
- C. 3
- D. 4
- E. 5

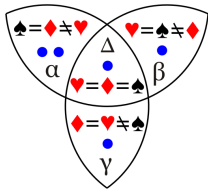
7. If you play the solitaire game 6 times, you will on average lose \_\_\_\_ times.<sup>333</sup>

- A. 4
- B. 2**
- C. 3
- D. 6
- E. 5

8. If you play the solitaire game 3 times, you will on average win \_\_\_\_ times.<sup>334</sup>

- A. 1
- B. 2**
- C. 3
- D. 4
- E. 5

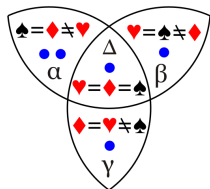
## 41 d\_Venn



1. Calculate the measured probability:  $P(\heartsuit, \diamondsuit) = ?$  Assume the dots represent five observations.<sup>335</sup>

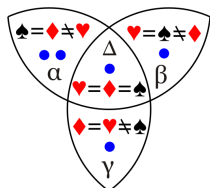
- A.  $2/4=1/2$
- B.  $2/5$
- C.  $3/5$**
- D.  $3/4$
- E.  $5/6$

The next page might contain more answer choices for this question



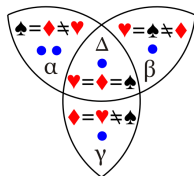
2. Calculate the measured probability:  $P(\spadesuit, \heartsuit) = ?$  Assume the dots represent five observations.<sup>336</sup>

- A.  $2/4=1/2$
- B.  $2/5$**
- C.  $3/5$
- D.  $3/4$
- E.  $5/6$



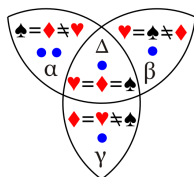
3. Calculate the probability  $P(\spadesuit, \diamondsuit) + P(\spadesuit, \heartsuit) + P(\heartsuit, \diamondsuit) = ?$  Assume the dots represent five observations.<sup>337</sup>

- A.  $4/5$
- B.  $5/6$
- C.  $5/4$
- D.  $6/5$
- E.  $7/5$**



4. Calculate the quantum correlation:  $C(\spadesuit, \diamondsuit) = ?$  Assume the dots represent five observations.<sup>338</sup>

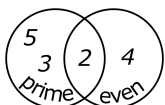
- A.  $-2/5$
- B.  $-1/5$
- C. 0
- D.  $+1/5$**
- E.  $+2/5$
- F. +1



5. Calculate the measured quantum correlation:  $C(\spadesuit, \heartsuit) = ?$  Assume the dots represent five observations.<sup>339</sup>

- A.  $-2/5$
- B.  $-1/5$**
- C. 0

D.  $+1/5$ E.  $+2/5$ F.  $+1$ 

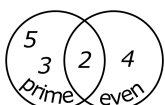
6.  If a number is randomly selected from the set 2,3,4,5, what is  $P(\text{even})$ , or the probability that the number is even?<sup>340</sup>

A. 0

B.  $1/4$ **C.  $1/2$** D.  $3/4$ 

E. 1

F.  $5/4$ 

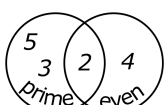
7.  If a number is randomly selected from the set 2,3,4,5, what is  $P(\text{prime})$ , or the probability that the number is prime?<sup>341</sup>

A. 0

B.  $1/4$ C.  $1/2$ **D.  $3/4$** 

E. 1

F.  $5/4$ 

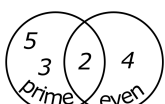
8.  If a number is randomly selected from the set 2,3,4,5, what is  $P(\text{prime})+P(\text{even})$ , or the sum of the probability that it is even, plus the probability that it is prime?<sup>342</sup>

A. 0

B.  $1/4$ C.  $1/2$ D.  $3/4$ 

E. 1

**F.  $5/4$** 

9.  If a number is randomly selected from the set 2,3,4,5, what is the probability that it is both even and prime?<sup>343</sup>

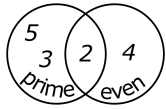
A. 0

**B.  $1/4$** 

The next page might contain more answer choices for this question

C.  $1/2$ D.  $3/4$ 

E. 1

F.  $5/4$ 

10. If a number is randomly selected from the set 2,3,4,5, what is the probability that it is either even or prime?<sup>344</sup>

A. 0

B.  $1/4$ C.  $1/2$ D.  $3/4$ **E. 1**F.  $5/4$ 

## 42 Attribution

### Notes

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<sup>21</sup> Example 5.2 from OpenStax University Physics2: [https://cnx.org/contents/eg-XcBxE@9.8:UtVGui9n@7/53-Coulombs-Law\\_1](https://cnx.org/contents/eg-XcBxE@9.8:UtVGui9n@7/53-Coulombs-Law_1) placed in Public Domain by Guy Vandegrift: <https://en.wikiversity.org/wiki/special:permalink/1894334>

<sup>22</sup> Example 5.2 from OpenStax University Physics2: [https://cnx.org/contents/eg-XcBxE@9.8:UtVGui9n@7/53-Coulombs-Law\\_1](https://cnx.org/contents/eg-XcBxE@9.8:UtVGui9n@7/53-Coulombs-Law_1) placed in Public Domain by Guy Vandegrift: <https://en.wikiversity.org/wiki/special:permalink/1894334>

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