104ex1

Physics 104 Exam 1

Name DEL ID #

Section # TA Name

Fill in your name, student ID # (not your social security #), and section # on the scantron sheet. Fill in the letters given for the first 5 questions on the scantron sheet. These letters determine which version of the test you took and are IMPORTANT to get right.

1. C

2. B

3. E

4. A

5. D

6. Two point charges, separated by 1.5 cm, have charges of +2.0 μC and -4.0 μC, respectively. Suppose you determine that 10 field lines radiate out from the +2.0 μC charge. If so, what might be inferred about the -4.0 μC charge with respect to field lines?

   [✓ a.] 20 radiate in
   b. 10 radiate in
   c. 5 radiate out
   d. 20 radiate out
   e. 10 radiate out

10 FIELD LINES FROM +2.0μC
\# FIELD LINES PROPORTIONAL TO FIELD STRENGTH; FIELD STRENGTH PROPORTIONAL TO CHARGE ⇒ 20 TO −4.0μC

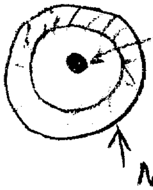
7. An electron with a charge of -1.6×10^{-19} C is moving in an electric field of 400 N/C. What force does the electron experience?

   a. 2.3×10^{-22} N
   b. 1.9×10^{-21} N
   [✓ c.] 6.4×10^{-17} N
   d. 4.9×10^{-17} N
   e. 3.2×10^{-17} N

$F = qE = -1.6\times10^{-19} \times 400 = 6.4\times10^{-17}$

8. You have a hollow metallic sphere with charge -5.0 μC and radius 5.0 cm. You insert a +10 μC charge at the center of the sphere through a hole in the surface. What charge now rests on the outer surface of the sphere?

   a. +15 μC
   b. -5 μC
   c. +10 μC
   [✓ d.] +5 μC
   e. -10 μC



−10μC INDUCED ON THE INSIDE OF THE OUTER SPHERE.

OVERALL +5μC
IT IS ON THE OUTSIDE BECAUSE A GAUSSIAN SURFACE INSIDE THE METAL HAS NO FLUX THROUGH IT AND ENCLOSES NO NET CHARGE

9. You wish to use a positively charged rod to charge a ball by induction. Which statement is correct?

   a. The ball must be an insulator that is connected temporarily to the ground.
   b. The ball is charged as the area of contact between the two increases.
   [✓ c.] The ball must be a conductor.
   d. The charge on the ball will be positive.
   e. The ball must be an insulator.

TO ADD CHARGE TO THE BALL BY INDUCTION IT MUST BE CONDUCTED FROM SOMEWHERE.

10. The beam of electrons that hits the screen of an oscilloscope is moved up and down by:

   a. the electron gun.
   [✓ b.] electrical charges on deflecting plates.
   c. a phosphorescent coating.
   d. gravity.
   e. electrical charges on the screen.

BEAM PASSES THROUGH ELECTRIC FIELD BETWEEN CHARGE PLATES.

11. Two point charges of values +3.4 μC and +6.6 μC are separated by 0.10 m. What is the electrical potential at the point midway between the two point charges? ($k = 9 \times 10^9$ N-m²/C²)

   a. $+0.9 \times 10^6$ V
   b. $+3.6 \times 10^6$ V
   c. -0.9×10^6 V
   [✓ d.] $+1.8 \times 10^6$ V
   e. -1.8×10^6 V

$r_1 = r_2 = 0.05\,m$ (MIDWAY)

$$V = \frac{k_e q_1}{r_1} + \frac{k_e q_2}{r_2} \qquad V = \frac{k_e}{r_1}(q_1+q_2) =$$

$$V = \frac{9\times10^9 \times (3.4+6.6)\times10^{-6}}{0.05} = 1.8\times10^6$$

12. An electron in a cathode ray tube is accelerated through a potential difference of 5 kV. What kinetic energy does the electron gain in the process? ($q_e = -1.6 \times 10^{-19}$ C)

   a. 1.6×10^{-16} J
   [✓ b.] 8.0×10^{-16} J
   c. 1.6×10^{-22} J
   d. 8.0×10^{-22} J
   e. 4.0×10^{-16} J

1 ELECTRON THROUGH 1 VOLT = 1 eV

SO 5 keV = 5×10^3 eV × 1.6×10^{-19} J/eV

$= 8\times10^{-16}$ J

13. Two capacitors with capacitances of 1.0 and 0.5 μF, respectively, are connected in parallel. The system is connected to a 100 V battery. What electrical potential energy is stored in the 1.0 μF capacitor?

   a. 1.7×10^{-3} J
   b. 7.5×10^{-3} J
   [✓ c.] 5.0×10^{-3} J
   d. 10.0×10^{-3} J
   e. 2.5×10^{-3} J

BOTH CAPACITORS CHARGED TO 100V

FOR EACH, EPE = $\frac{1}{2}CV^2$

FOR 1.0μF, EPE = $\frac{1}{2}(1\times10^{-6})(100)^2$

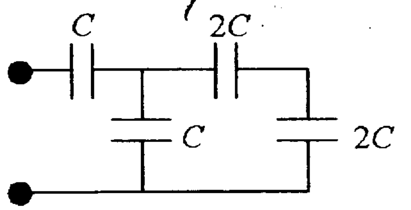
$= 5\times10^{-3}$ J

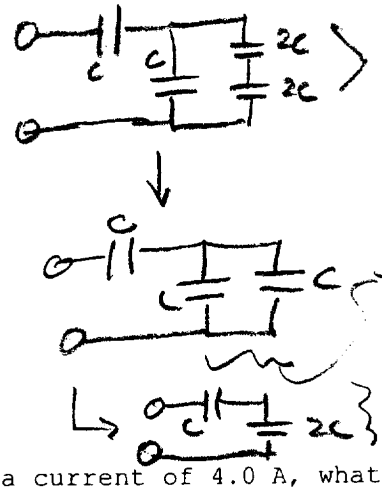
14. In which case does an electric field do positive work on a charged particle?

    a. a positive charge completes one circular path around a stationary positive charge. TRAVELING PERPENDICULAR TO FIELD - NO
    b. a positive charge completes one elliptical path around a stationary positive charge. NO NET CHANGE IN POSITION - NO
    c. a positive charge is moved to a point of higher potential energy. ← YOU HAVE TO DO WORK AGAINST THE FIELD
    [✓ d.] a negative charge moves opposite to the direction of the electric field. YES, HERE THE CHARGE IS PULLED BY THE FIELD.
    e. a positive charge moves opposite to the direction of the electric field. YOU HAVE TO DO WORK AGAINST THE FIELD

15. If C = 36 μF, determine the equivalent capacitance for the combination shown.

    a. 36 μF
    b. 32 μF
    c. 28 μF
    [✓ d.] 24 μF
    e. 20 μF





EQUIVALENT;

$\frac{1}{C'} = \frac{1}{2C} + \frac{1}{2C} = \frac{2}{2C}$

$C' = C$

EQUIVALENT; $C+C=2C$

EQUIVALENT; $\frac{1}{C'} = \frac{1}{C} + \frac{1}{2C} = \frac{3}{2C}$

$C' = 2C/3$

16. If a 500 W heater carries a current of 4.0 A, what is the resistance of the heating element?

    [✓ a.] 31.3 Ω
    b. 11.2 Ω
    c. 42.8 Ω
    d. 85.7 Ω
    e. 62.6 Ω

$P = I^2R = (4.0)^2 R = 500\ W$

$R = \frac{500}{16} = 31.3\ \Omega$

17. A 500 W heater carries a current of 4.0 amperes. How much does it cost to operate the heater for 30 minutes if electrical energy costs 6 cents per kW-hr?

    a. 18.0 cents
    b. 36.0 cents
    c. 9.0 cents
    [✓ d.] 1.5 cents
    e. 3.0 cents

$500\ W \times \frac{1}{2}\ HR = 0.5\ kW \times 0.5\ HR = 0.25\ kWH$

$0.25\ kWH \times 6¢/kWH = 1.5¢$

18. An electric clothes dryer draws 15 A at 220 V. If the clothes put into the dryer have a mass of 7 kg when wet and 4 kg dry, how long does it take to dry the clothes? (Assume all heat energy goes into vaporizing water, $L_{vap} = 2.26 \times 10^6$ J/kg.)

a. 20.0 min
b. 15.6 min
[✓ c. 34.2 min]
d. 55.1 min
e. 26.4 min

3 kg OF WATER VAPORIZED; $3\text{ kg} \times 2.26\times10^6\text{ J/kg} = 6.78\times10^6\text{ J}$, $P = IV = 15 \times 220 = 3.3\times10^3\text{ W}$

$\frac{6.78\times10^6\text{ J}}{3.3\times10^3\text{ J/s}} = 2.05\times10^3\text{ s}$ $\frac{2.05\times10^3\text{ s}}{60\text{ s/MIN}} = 34.2\text{ MIN}$

19. When you flip a switch to turn on a light, the delay before the light turns on is determined by:

[✓ a. the speed of the electric field moving in the wire.]
b. the density of electrons in the wire.
c. the drift speed of the electrons in the wire.
d. the number of electron collisions per second in the wire.
e. none of these, since the light comes on instantly.

AS SOON AS THE E HITS THE BULB, ELECTRONS MOVE IN THE BULB AND THE LIGHT COMES ON.

20. A platinum wire is utilized to determine the melting point of indium. The resistance of the platinum wire is 2 Ω at 20°C and increases to 3.072 Ω as the indium starts to melt. $\alpha_{platinum} = 3.92 \times 10^{-3}/°C$. What is the melting temperature of indium?

a. 351°C
b. 731°C
[✓ c. 157°C]
d. 137°C
e. 430°C

$R = \rho L/A$ so $\frac{R}{R_0} = \rho/\rho_0$

$\rho = \rho_0(1 + \alpha(T - T_0))$

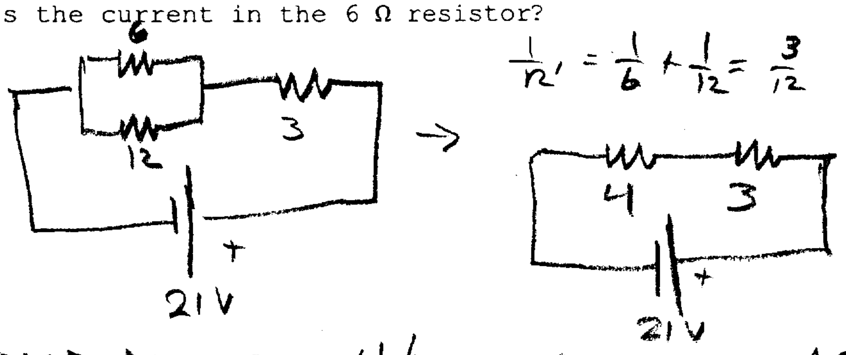
$\frac{R}{R_0} = 1 + \alpha(T - T_0) = \frac{3.072}{2} = 1.536$ $\alpha(T - T_0) = 0.536$

$T - T_0 = 0.536/\alpha = 0.536/3.92\times10^{-3} = 137°$; $T_0 = 20°C$

21. Two resistors of values 6 Ω and 12 Ω are connected in parallel. This combination in turn is connected in series with a 3 Ω resistor and a 21 V battery. What is the current in the 6 Ω resistor?

a. 12.0 A
b. 3.0 A
[✓ c. 2.0 A]
d. 4.0 A
e. 6.0 A

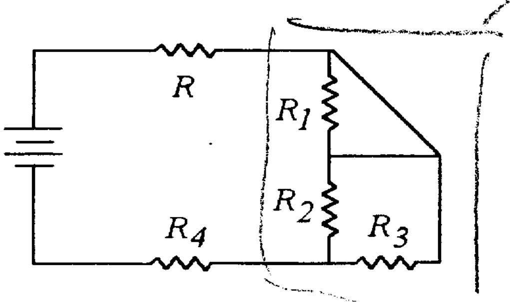
$\frac{1}{R'} = \frac{1}{6} + \frac{1}{12} = \frac{3}{12}$ $R' = 4$



THIS IS A VOLTAGE DIVIDER - 4/(4+3) OF THE 21 V APPEARS ACROSS THE 4 Ω, $21 \times \frac{4}{7} = 12$ V ACROSS 4 Ω.
THIS 12 V IS ACROSS THE 6 AND 12 Ω RESISTORS SIMULTANEOUSLY. $I = V/R = 12\text{V}/6\Omega = 2$ A

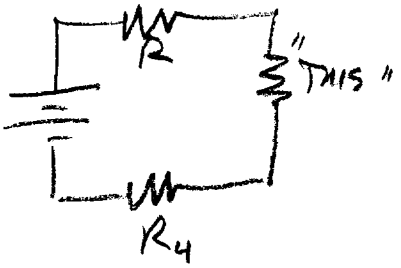
22. Which resistor is in series with resistor R?

a. R_1
b. R_2
c. R_3
[✓ d.] R_4
e. none of the above



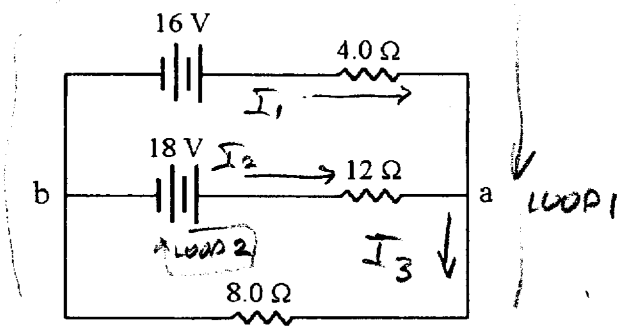
THIS* IS IN SERIES WITH R, AND SO IS R4.

* REDUCE IT TO AN EQUIVALENT SINGLE RESISTOR TO SEE



23. What is the current through the 8 Ω resistor?

a. 1.0 A
b. 0 5 A
[✓ c.] 1.5 A
d. 2.0 A
e. 3.0 A



$I_1 + I_2 = I_3$

LOOP 1: $+16 - 4I_1 - 8I_3 = 0$

LOOP 2: $+18 - 12I_2 - 8I_3 = 0$

SUBSTITUTE FOR I_1, LOOP 1:

$16 - 4(I_3 - I_2) - 8I_3 = 0$

$16 + 4I_2 - 12I_3 = 0$

MULTIPLY × 3

$+48 + 12I_2 - 36I_3 = 0$

ADD TO LOOP 2 EQUATION

$+18 - 12I_2 - 8I_3 = 0$

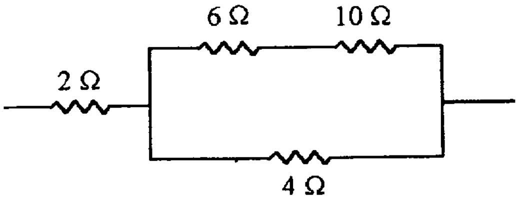
$+66 + 0 - 44I_3 = 0$

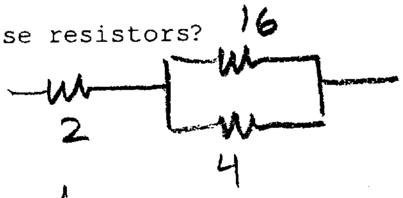
$66 = 44I_3$

$I_3 = 1.5$ A

24. What is the equivalent resistance for these resistors?

- a. 2.3 Ω
- b. 2.25 Ω
- c. 3.0 Ω
- d. 22 Ω
- [✓ e. 5.2 Ω]

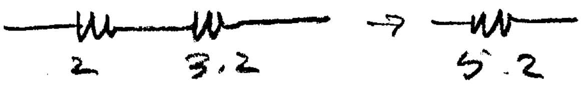




↓

$\frac{1}{r} = \frac{1}{16} + \frac{1}{4} = \frac{1}{16} + \frac{4}{16} = \frac{5}{16}$

$R = 16/5 = 3.2$



25. Two resistors of values 6 Ω and 12 Ω are connected in parallel. This combination in turn is connected in series with a 3 Ω resistor and a 21 V battery. What is the current in the 6 Ω resistor?

- a. 12.0 A
- b. 3.0 A
- [✓ c. 2.0 A] SAME AS #21
- d. 4.0 A
- e. 6.0 A