Post Mon. 2/24 104ex1

Physics 104 Exam 1 February 20, 2003

Name DEL ID #_____

Section #_____ TA Name_____

Fill in your name, student ID # (not your social security #), and section # (under ABC of special codes) 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 it is very important to get this right. Make sure your exam has questions 6—25.

1. C

2. B

3. D

4. A

5. E

6. What is the direction of the electric field at the surface of a negatively charged conductor?

   a. tangent to the surface
   b. at a 45° angle to the surface
   c. perpendicular outward and away from the charge
   d. none of the above; the electric field is zero
   (e.) perpendicular inward toward the charge

7. The units of electric field are

   a. $kg \cdot m^2/C \cdot s^2$
   b. $kg \cdot m^3/C^2 \cdot s^2$
   c. $kg \cdot m/C^2 \cdot s^2$
   (d.) $kg \cdot m/C \cdot s^2$
   e. $kg/C \cdot s^2$

$\frac{\text{NEWTONS}}{\text{COULOMB}} = \frac{kg\ M}{S^2 C}$

$F = qE$

$\text{NEWTONS} = \text{COULOMB} \times \frac{\text{NEWTONS}}{\text{COULOMB}}$

8. Two identical balls in free space have the same amount of charge, but the charge on ball A is positive and the charge on ball B is negative. Which one of the following is true?

   a. They will move toward one another. OPPOSITE CHARGES ATTRACT
   b. Since the force on A is equal but opposite to the force on B, they will not move.
   c. They will move with constant acceleration. (NO, FORCE INCREASES AS CLOSER DISTANCES)
   d. Since the force on both balls is negative they will move in the negative direction.
   e. The will move away from one another.

9. An oil drop of radius 1.6×10^{-4} cm with a charge equivalent to one electron is suspended in an electric field such that the electric force just balances the gravitational force on the drop. What is the magnitude of the electric field? (The density of oil is 0.85 g/cm^3, and $e = 1.6 \times 10^{-19}$ C.)

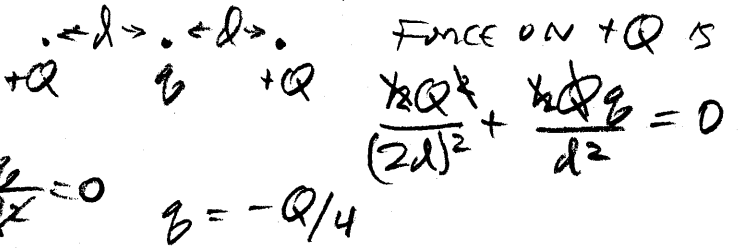
   m = MASS OF DROP = DENSITY × VOLUME = $\rho V = \rho \frac{4}{3}\pi r^3$

   a. 1.1×10^5 V/m
   b. 8.9×10^5 V/m $|F_E| = qE = mg = |F_{GRAVITY}|$ $q = e$
   c. 2.2×10^5 V/m
   d. 4.5×10^5 V/m So $E = \frac{mg}{e} = \frac{4\pi r^3 \rho g}{3e}$ $r = 1.6 \times 10^{-2}$ m
   e. zero

   $\rho = 0.85\ g/cm^3 = 8.5 \times 10^{-4}\ kg / (10^{-2}\ m)^3 = 850\ kg/m^3$

10. Two equal charges, each +Q, are separated by some distance. What third charge would need to be placed half way between the two charges so that the net force on each charge would be zero?

    a. –Q/4
    b. –Q
    c. –Q/2
    d. –Q/8
    e. –2Q

    FORCE ON +Q IS $\frac{kQ^2}{(2d)^2} + \frac{kQq}{d^2} = 0$

    $\frac{Q}{4d^2} + \frac{q}{d^2} = 0$ $q = -Q/4$

11. Increasing the separation of the two charged parallel plates of a capacitor, which are disconnected from a battery, will produce what effect on the capacitor?

    a. increase charge
    b. decrease charge
    c. increase capacitance
    d. decrease voltage
    e. decrease capacitance

    DISCONNECT → CHARGE STAYS SAME

    $C = \frac{\varepsilon_0 A}{d}$ So C↓ IS d↑

    $V = Q/C$ So V↑ IS C↓

12. Find the electrical potential 15 cm from a point charge of 3.0 μC. ($k = 8.99 \times 10^9$ N·m^2/C^2)

a. 2.7×10^4 V
b. 1.2×10^6 V
c. 6.0×10^6 V
d. 3.6×10^5 V
e. 1.8×10^5 V

$\frac{kq}{r} = \frac{8.99 \times 10^9 \times 3.0 \times 10^{-6}}{15 \times 10^{-2}} = 105$

$\frac{9 \times 3}{5} \times 10^5 = 1.8 \times 10^5$

13. Two capacitors with capacitances of 1.0 and 0.50 μF, respectively, are connected in series. The system is connected to a 100-V battery. What electrical potential energy is stored in the 1.0-μF capacitor?

a. 0.065×10^{-3} J
b. 4.3×10^{-3} J
c. 0.80×10^{-3} J
d. 5.6×10^{-4} J
e. 5.0×10^{-3} J

1.0 0.50 → C $\frac{1}{C} = \frac{1}{1} \times \frac{1}{.5} = 3$

$C = \frac{1}{3}\mu F$ $Q = CV = \frac{1}{3} \times 10^{-6} \times 100 = 10^{-4}$

$Q = \frac{1}{3} \times 10^{-4}$ C ON BOTH CAPACITORS.

STORED E IS $\frac{1}{2}\frac{Q^2}{C}$

$= \frac{\frac{1}{2}\left(\frac{1}{3} \times 10^{-4}\right)^2}{1 \times 10^{-6}}$

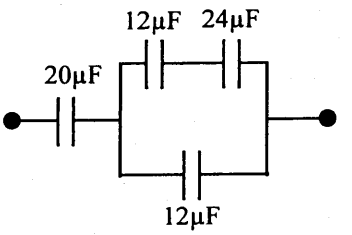
$= \frac{10^{-2}}{2.3^2}$

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

a. a negative charge moves opposite to the direction of the electric field.
b. a positive charge is moved to a point of higher potential energy. — WORK
c. a positive charge completes one circular path around a stationary positive charge. NO WORK
d. a negative charge is moved to a point of higher potential energy. — WORK
e. a negative charge moves in the direction of the electric field — WORK

15. What is the equivalent capacitance of the combination shown?

a. 29 μF
b. 40 μF
c. 25 μF
d. 15 μF
e. 10 μF



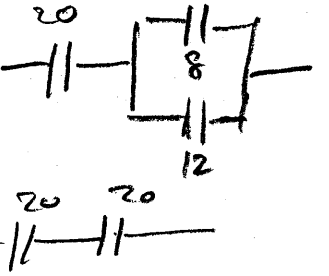
12 AND 24 IN SERIES

$\frac{1}{C} = \frac{1}{12} + \frac{1}{24} = \frac{3}{24}$ $C = 8$

8 AND 12 IN PARALLEL $C = 20$

20 AND 20 IN SERIES $C = 10$

$\frac{1}{C} = \frac{1}{20} + \frac{1}{20} = \frac{1}{10}$



16. If a metallic wire of cross sectional area 3.0×10^{-6} m^2 carries a current of 6.0 A and has a mobile charge density of 4.24×10^{28} carriers/m^3, what is the average drift velocity of the mobile charge carriers? (charge $= 1.6 \times 10^{-19}$ C)

a. 3.4×10^{3} m/s
b. 1.7×10^{3} m/s
c. 1.5×10^{-4} m/s
d. 2.9×10^{-4} m/s
e. 3.4×10^{-4} m/s

$I = nqv_dA$

$v_d = I/nqA = \frac{6}{4.24\times10^{28}\times1.6\times10^{-19}\times3.0\times10^{-6}}$

$v_d = 2.9\times10^{-4}$

17. The current in an electron beam in a cathode-ray tube is 70 μA. How many electrons hit the screen in 5.0 s? ($e = 1.6 \times 10^{-19}$ C)

a. 2.2×10^{11} electrons
b. 8.8×10^{13} electrons
c. 8.8×10^{18} electrons
d. 2.2×10^{15} electrons
e. 2.2×10^{18} electrons

$70\,\mu A = 70\,\mu C$ IN 1 S.

$5 \times 70 = 350\,\mu C$ IN 5 S.

$\frac{350\times10^{-6}}{1.6\times10^{-19}} = 220\times10^{+13} = 2.2\times10^{+15}$

18. A certain material is in a room at 27°C. If the absolute temperature (K) of the material is tripled, its resistance doubles. (Water freezes at 273 K.) What is the value for α, the temperature coefficient of resistivity?

a. 0.0017/°C
b. 1/°C
c. 2/°C
d. 0.038/°C
e. 0.667/°C

$27°C \rightarrow 27+273 = 300\,K$ TRIPLED IS 900K SO $\Delta T = 600K = 600C$

$(1 + \alpha\Delta T) = 2$ (RESISTANCE DOUBLES)

$\alpha\Delta T = 1 \quad \alpha \times 600 = 1 \quad \alpha = 1/600$

19. A water pump draws about 3.8 A when connected to 240 V. What is the cost (with electrical energy at 9 cents per kWh) of running the pump for 5 h?

a. 8.0 cents
b. 15 cents
c. 82 cents
d. 95 cents
e. 41 cents

$P = I\,\Delta V = 3.8A \times 240V = 912\,W = 0.912\,kW$

$0.912\,kW \times 5\,h = 4.56\,kWh$

$4.56 \times \$.09 = \$0.41$

20. An electric car is designed to run off a bank of 12-V batteries with a total energy storage of 6.0×10^7 J. If the electric motor consumes 6 kW in moving the car at a steady speed of 10 m/s, how far will the car go before it is "out of juice?"

a. 25 km
b. 100 km
c. 50 km
d. 150 km
e. 200 km

$6\text{ kW} = 6000\text{ W} = 6000\text{ J/s} = 6\times10^3$

$\frac{6\times10^7\text{ J}}{6\times10^3\text{ J/s}} = 10^4\text{ s}$

$10\text{ m/s} \times 10^4\text{ s} = 10^5\text{ m} = 100\text{ km}$

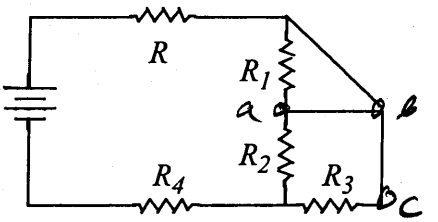
21. Three resistors, with values of 2.0, 4.0 and 8.0 Ω, respectively, are connected in parallel. What is the equivalent resistance of this combination?

a. 0.58 Ω
b. 7.0 Ω
c. 1.1 Ω
d. 14.0 Ω
e. 4.57 Ω

R IN PARALLEL $\rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{8}$

$\frac{1}{R} = \frac{4}{8} + \frac{2}{8} + \frac{1}{8} = \frac{7}{8}$ $R = 8/7$

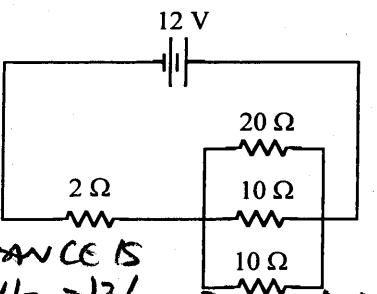
22. Which two resistors are in parallel with each other?



a. R and R_4
b. R_2 and R_4
c. R and R_1
d. R_2 and R_3
e. R_1 and R_2

POTENTIAL IS THE SAME AT a, b, c SO R_2 AND R_3 HAVE SAME POTENTIAL AT BOTH ENDS.

23. How much power is dissipated by one of the 10-Ω resistors?

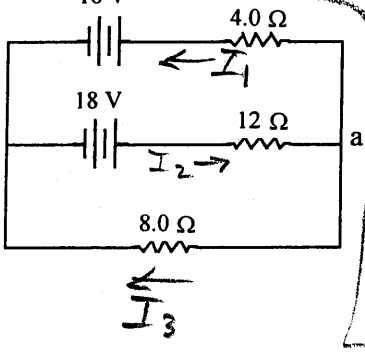


a. 24 W
b. 9.6 W
c. 6.4 W
d. 16 W
e. 3.2 W

RESISTANCE OF 10, 10, 20 IN PARALLEL IS $\frac{1}{R} = \frac{1}{10} + \frac{1}{10} + \frac{1}{20} = \frac{5}{20}$

$R = 4$ TOTAL RESISTANCE IS THEN $R + 2 = 6$, $I = V/R = 12/6 = 2$ A, POTENTIAL ACROSS PARALLEL R IS $V_{\parallel} = IR = 2\times4 = 8$ V. POWER IN 10Ω RESISTOR WITH 8V ACROSS IT IS $P = \frac{\Delta V^2}{R}$ $P = \frac{64}{10}$

24. What is the potential difference between points a and b?



a. 12 V
b. 6 V
c. 8 V
d. 24 V
e. 18 V

$I_2 = I_1 + I_3$ (JUNCTION)

TOP LOOP CLOCKWISE!

$+16 + 4I_1 + 12I_2 - 18 = 0$

OR $2I_1 + 6I_2 - 1 = 0$ (1)

OUTSIDE LOOP CLOCKWISE

$+16 + 4I_1 - 8I_3 = 0$ OR

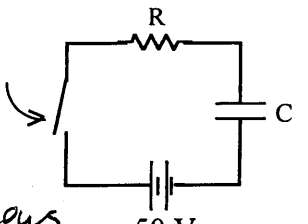
$4 + I_1 - 2I_3 = 0$ (2)

PUT $I_3 = I_2 - I_1$ (JUNCTION) IN (2) $\rightarrow 4 + 3I_1 - 2I_2 = 0$; MULTIPLY BY 3 $\rightarrow$

$\rightarrow 12 + 9I_1 - 6I_2 = 0$ ADD TO (1) $\rightarrow 11 + 11I_1 = 0$ $I_1 = -1$ (WRONG ARROW!)

NOW FROM a TO b ALONG TOP IS $+16 - 1\times4\,\Omega = 12$ V (− B/C ARROW IS WRONG)

25. A series *RC* circuit has a time constant of 1.0 s. The battery has a voltage of 50 V and the maximum current just after closing the switch is 500 mA. The capacitor is initially uncharged. What is the charge on the capacitor 2.0 s after the switch is closed?



a. 0.86 C
b. 0.99 C
c. 0.43 C
d. 0 66 C
e. 0.50 C

IF 500mA = 0.5A FLOWS WITH NO CHARGE ON THE CAPACITOR, THERE IS 50 V ON THE RESISTOR, SO

$R = \frac{V}{I} = \frac{50}{0.5} = 100\ \Omega$

$RC = 1$ SO $C = 1/100 = 0.01$ F (NOT μF!)

$Q_{MAX} = CV_{MAX} = .01\text{F} \times 50\text{V} = 0.50\text{C}$

AFTER 2 S $Q = Q_{MAX}(1 - e^{-2/1})$

$Q = Q_{MAX}(1 - 0.14) = 0.43\text{C}$

Physics 104 Exam 1 - February 20, 2003

1	A	B	C
2	C	C	B
3	E	D	D
4	B	A	A
5	D	E	E
6	B	C	E
7	D	A	D
8	A	E	A
9	D	B	B
10	B	E	A
11	E	C	E
12	A	B	E
13	C	E	D
14	E	E	A
15	B	E	E
16	D	E	D
17	A	A	D
18	C	A	A
19	A	D	E
20	E	B	B
21	B	B	C
22	C	D	D
23	D	C	C
24	A	E	A
25	D	A	C