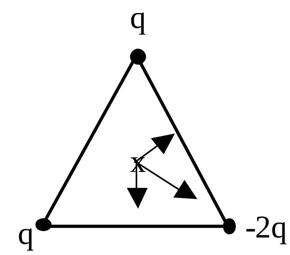
Practice Final: PHY 232 Spring 2002

1. Three charges (q,q,-2q) are placed at the corners of an equilateral triangle. Consider the point which is equidistant from the three sides of the triangle. At that point which one of the following statements is true? (Remember: **E** is a vector, *V* is a scalar)



A) Both the electric field and the electric potential are zero.

B) The electric field is zero but the electric potential is not.

C) **<u>The electric potential is zero but the electric field is not.</u>**

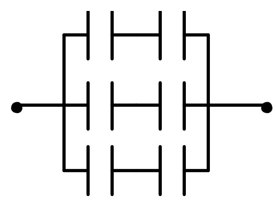
D) Both the electric field and the electric potential are non-zero.

E) The net force on a negative charge is zero but on a positive charge it is non-zero.

2. Six identical capacitors (capacitance C) are connected as shown in the diagram to the right. What is the total capacitance of the combination?

A) 9C
B) 6C
C) <u>3C/2</u>
D) 2C/3
E) C/6

For two C's in series, C_{eq} = C/2. For three C_{eq} in parallel, C_{total} = 3C_{eq} = 3C/2.



3. When a fully discharged C = 3.2 μF capacitor is charged through a R = 100 Ω resistor, how long does it take to reach 0.63% less than its final voltage?

A) 2.7 msec
B) 320 μsec
C) 130 μsec
D) 210 msec
E) <u>1.6 msec</u>

Time constant $\tau = RC = 3.2\times10^{-4}$ s. Also

$V(t)/V_{\text{final}} = (1-e^{-t/t}) = 1-6.3\times10^{-3} \;\Rightarrow\; 6.3\times10^{-3} = e^{-t/t}$.

Then $\ln(6.3\times10^{-3}) = -5.07 = -t/t \;\Rightarrow\; t = 1.62\times10^{-3}$ s.

4. A 2.0 μF capacitor and a 3.0 mH inductor are connected in series with an AC power supply. At what frequency will the inductive reactance be three times the capacitive reactance?

A) 1.8×10^{-8} Hz

B) <u>3.6×10^{3} Hz</u>

C) 2.1×10^{3} Hz

D) 570 Hz

E) 1.3×10^{4} Hz

Given $X_L = 3X_C = 2pfL = \dfrac{3}{2pfC} \;\Rightarrow\; (2pf)^2 = \dfrac{3}{LC}$

Then $f = \dfrac{1}{2p}\sqrt{\dfrac{3}{LC}} = 3.6\times10^{3}$ Hz

5. What is the distance between two $q_1 = q_2$ = 5 μC charges if the Coulomb force between them is $F = 4.6\times10^{3}$ N?

A) 14.2 m

B) <u>7.0×10^{-3} m</u>

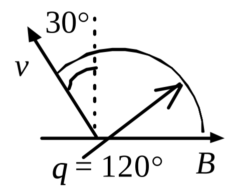
C) 9.8×10^{-3} m

D) 9.8 m

E) 3.5×10^{-2} m

$F = \dfrac{k_e q_1 q_2}{r^2} \;\Rightarrow\; r = \sqrt{\dfrac{k_e q_1 q_2}{F}} = 7.0\times10^{-3}$ m

6. A charge of $q = +3\ \mu C$ is traveling with a velocity of $v = 2\times10^5$ m/sec at an angle of 30° to the y-direction in a $B = 0.33$ T magnetic field which points in the x-direction as shown. What is the magnitude and direction of the force on the charge?



A) zero
B) <u>0.17N, into the page</u>
C) 0.17N, out of the page
D) 0.10N, out of the page
E) 0.10N, into the page

> $F = qvB\sin(q) = 0.17$ N, with $q = 120°$.
> Right-hand rule gives, ***F*** into page.

7. What is the rate of change of the current $\Delta I/\Delta t$ in a coil with an inductance of $L = 250\ \mu H$ which has a voltage of $\mathcal{E} = 25V$ induced across it?

A) 1.0 A/s
B) 1.0×10^2 A/s
C) <u>1.0´10^5 A/s</u>
D) 1.3×10^{12} A/s
E) 1.0×10^{11} A/s

> Given $|e| = L\dfrac{\Delta I}{\Delta t} \Rightarrow \dfrac{\Delta I}{\Delta t} = \dfrac{e}{L} = 1.0\times10^5$ A/s.

8. A proton (mass = 1.67×10^{-27} kg) is accelerated from rest through a potential of $\Delta V = 2.50\times10^5$ V. What is its final speed?

A) 4.79×10^{12} m/s
B) <u>6.92´10^6 m/s</u>
C) 2.99×10^8 m/s
D) 4.89×10^6 m/s
E) 1.73×10^6 m/s

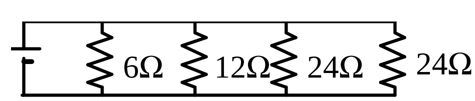
> $\frac{1}{2}m_p v^2 = e\Delta V \Rightarrow v = \sqrt{\dfrac{2e\Delta V}{m_p}} = 6.92\times10^6$ m/s

9. An electric water heater of resistance $R = 8\ \Omega$ draws $I = 15$ A of current when connected to the voltage supply. What is the cost of operating the water heater for a period of <u>12 hours</u> if the electric company charges \$0.10/kW·hour?

A) 3 dollars and 60 cents
B) 15 cents
C) <u>2 dollars and 16 cents</u>
D) 13 dollars and 80 cents
E) 72 cents

> Use $P = I^2R = 1.8$ kW. For 12 h, energy used
> $U = 1.8\times12$ kW-h = 21.6 kW-h = \$2.16.

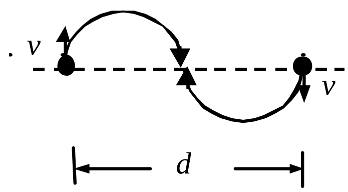
10. Four resistors are connected in parallel to a voltage source as shown in the diagram to the right. The 6 Ω resistor carries a current of 3 A. What is the total current supplied by the battery to the resistors?



A) 15 A
B) 12 A
C) 9 A
D) <u>6 A</u>
E) 3 A

> For battery, $\Delta V = IR = 3A\cdot6\Omega = 18$ V,
> and R_{eq} of resistor network = 3.0 Ω. Thus $I_{total} = \Delta V/R_{eq} = 6.0$ A.
> For resistors, note that the two 24Ω resistor are in parallel, giving $R_{eq} = 12\Omega$. Then you have two 12Ω parallel resistors, giving $R_{eq} = 6\Omega$. Finally, you have two 6Ω resistors in parallel, giving $R_{eq} = 3\Omega$.

11. Two positive particles separated by a distance, *d*, with a charge, *q*, and mass, *m*, move initially with a velocity, *v*, in opposite directions, perpendicular to the line joining them. Since a magnetic field ***B*** will bend the particles into circular paths, what magnetic field is necessary to make them collide head-on? (Ignore the electric forces between the charges)



A) The particles must have opposite charges in order to collide.

B) $B = \frac{4mv}{qd}$, into the page.

C) $B = \frac{4mv}{qd}$ **, out of the page**.

D) $B = \frac{2mv}{qd}$, out of the page.

E) $B = \frac{2mv}{qd}$, into the page.

> Radius *r* of circles is *d*/4 and ***B*** must point out of page for force on *q* to point toward center of circle. Given $r = \frac{mv}{qB}$, then $B = \frac{mv}{qr} = \frac{4mv}{qd}$.

12. A sinusoidal voltage source powers a purely resistive circuit. In this circuit the current:

A) leads the voltage by 1/4 cycle
B) leads the voltage by 1/2 cycle
C) lags the voltage by 1/4 cycle
D) lags the voltage by 1/2 cycle
E) is in phase with the voltage

13. An electron passing through a single slit has its x-position determined to within 5×10^{-10} m. The (Heisenberg) uncertainty in the x-component of momentum is about:

A) 0
B) 10^{-27} kg · m/s
C) 10^{-25} kg · m/s
D) 10^{-21} kg · m/s
E) 10^{-19} kg · m/s

> Given:
> $\Delta x \cdot \Delta p_x \geq \frac{h}{4p} \Rightarrow \Delta p_x \geq \frac{h}{4p \cdot \Delta x} = 1.06\times 10^{-25}$ kg · m/s

14. The diameter of a hydrogen atom in its ground state is about

A) 10^{-23} m
B) 10^{-19} m
C) 10^{-15} m
D) 10^{-10} m
E) 10^{-7} m

> Diameter = $2 \cdot a_0$ where Bohr radius of ground state $a_0 = 5.3\times 10^{-11}$ m.

15. All nuclei with a Z>1 must contain neutrons because
A) they provide additional mass to increase the nuclear gravity
B) they fill the empty spaces between the protons
C) <u>they increase binding forces without increasing nuclear charge</u>
D) they decay to electrons that decrease the nuclear charge
E) they push the protons closer together.

16. A single concave spherical mirror produces an image which is

A) always virtual
B) always real
C) real only if the object distance is less than the focal length f
D) <u>real only if the object distance is greater than the focal length f</u>
E) real only if the object distance is equal to f

17. A diffraction grating has 6000 lines per centimeter ruled on it. What is the angular separation between the second and third order maxima (on the same side of the pattern) when the grating is illuminated with a beam of light of wavelength 550 nm?

A) 0^o
B) 30^o
C) <u>40.5^o</u>
D) 47.2^o
E) 53.4^o

Given d = (0.01m)/6000 = 1.667×10^{-6} m and $ml = d\cdot\sin(q_m)$.

Now $q_2 = \sin^{-1}\left(\frac{2l}{d}\right) = 41.3^\circ$ and $q_3 = \sin^{-1}\left(\frac{3l}{d}\right) = 81.8^\circ$.

Thus $\Delta q = q_3 - q_2 = 40.5°$.

18. With what color light would you expect to be able to see the greatest detail when using a microscope?

A) red, because of its long wavelength
B) red, because it is refracted less than other colors by glass
C) <u>blue, because of its shorter wavelength</u>
D) blue, because it is brighter
E) the color makes no difference in the resolving power, since this is determined only by the diameter of the lenses

19. An electron has a rest-mass energy of 511 keV. It is traveling down a linear accelerator so fast that its total energy is E = 40.88 MeV. The linear accelerator is L_p = 1000 m long. According to an observer hitching a ride on the electron, how long (L) is the linear accelerator?

A) 1000 m
B) <u>12.5 m</u>
C) 57.2 m
D) 69.1 m
E) 125 m

Given $E = g \cdot m_e c^2 \Rightarrow g = \frac{E}{m_e c^2} = \frac{40.88\,\text{MeV}}{0.511\,\text{MeV}} = 80$.

Next you have $L = \frac{L_p}{g} = \frac{1000\,\text{m}}{80} = 12.5\,\text{m}$

20. How much energy in joules, is carried by a photon of wavelength 660 nm?

A) 1.46×10^{-48} J

B) <u>3.01×10^{-19} J</u>

C) 6.63×10^{-34} J

D) 3.21×10^{-27} J

E) 1.95×10^{-22} J

$$E_{\text{photon}} = hf = \frac{hc}{l} = 3.01\times 10^{-19}\text{ J}$$

21. A metallic surface has a work function of f = 2.5 eV. What is the longest wavelength l that will eject electrons from the surface of this metal?

A) **<u>497 nm</u>**
B) 633 nm
C) 324 nm
D) 978 nm
E) 592 nm

Given $KE_{\max} = E_{\text{photon}} - f$. Longest l means minimum E_{photon} where $KE_{\max}$ = 0. Thus $E_{\text{photon}} = f = \frac{hc}{l}$.

Hence $l = \frac{hc}{f} = \frac{1.24\times 10^{-6}\ (\text{eV})\cdot\text{s}}{2.5\,\text{eV}} = 496\text{ m}$

22. Isotopes of an element have nuclei with

A) **<u>the same number of protons, but different numbers of neutrons</u>**
B) the same number of protons and the same number of neutrons
C) a different number of protons and a different number of neutrons
D) a different number of protons and the same number of neutrons
E) the same number of protons and neutrons but a different number of electrons

23. Suppose that in a certain collection of nuclei there were initially N_0 = 1024 nuclei and 20 minutes later, there was only N_{20} = 1 left. On the basis of this information, how many nuclei would you estimate **<u>decayed</u>** (= $N_0 - N_6$) in the first 6 minutes?

A) 512
B) 256
C) **<u>896</u>**
D) 1023
E) 64

Now $\frac{N_{20}}{N_0} = e^{-l\cdot 20}$. Then $\frac{1}{1024} = e^{-l\cdot 20} \Rightarrow \ln\left(\frac{1}{1024}\right) = -l\cdot 20 = -6.93$.

Thus l = 6.93/20min = 0.346/min and $N_6 = 1024\cdot e^{-0.346\times 6} = 128$.

Finally, $N_0 - N_6$ = 1024 – 128 = 896.

Alternative solution: 1024 = 2^{10}. Thus $N_{20}/N_0 = (1/2)^{10}$ (= 10 half-lives) and hence $T_{1/2}$ = 20min/10 = 2 min. Then at 6 minutes $N_6/N_0 = (1/2)^3$ (= 3 half-lives) and $N_0 - N_6$ = 1024(1 – 0.125) = 896.

24. What is the source of the energy the sun radiates to us

A) chemical reactions
B) nuclear fission reactions
C) **<u>nuclear fusion reactions</u>**
D) magnetic explosions
E) cosmic rays