Final Exam Review:

Representative short answer & problem from each chapter, with answer:

Chapter 18

Q) What process can allow heat to be transferred through a vacuum?

Radiation

P) In a certain solar house, energy from the Sun is stored in barrels filled with water. In a particular winter stretch of five cloudy days, 1.38×10^6 kcal is needed to maintain the inside of the house at 21°C. Assuming that the water in the barrels is at 52.8°C and that the water has a density of 1.00×10^3 kg/m^3, what volume of water is required? Take the specific heat of water to be 1.00 kcal/kg.

(* note kcal not SI units)

43.4 m^3

$Q = mc\Delta T$

$m = \frac{Q}{c\Delta T} = \frac{1.38\times10^6 \text{ kcal}}{\left(1 \frac{\text{kcal}}{\text{kg}\,C}\right)(52.8° - 21°)} = 43400 \text{ kg}$

K

$V = \frac{m}{\rho} = \frac{43400 \text{ kg}}{1000 \text{ kg/m}^3} = \boxed{43.4 \text{ m}^3}$

Chapter 19

Q) If an ideal gas expands isothermally, what direction does heat flow?

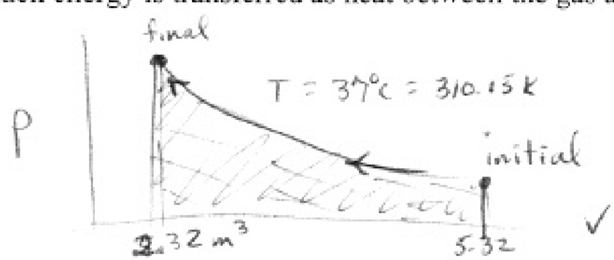
$\Delta E = Q - W$; as $\Delta E = \frac{3}{2} nR\Delta T$, $\Delta E = 0$ for isothermal, Thus $Q = W$

$W = +$ for expansion, so $Q = +$, heat flows in

P) An ideal gas undergoes isothermal compression from an initial volume of 5.32 m^3 to a final volume of 2.32 m^3. There is 2.31 mol of the gas, and its temperature is 37.0°C. **(a)** How much work is done by the gas? **(b)** How much energy is transferred as heat between the gas and its environment?

(a) -4940 J

(b) 4940 J



a) $W = nRT \ln(V_f/V_i) = -4943 \text{ J}$ (neg)

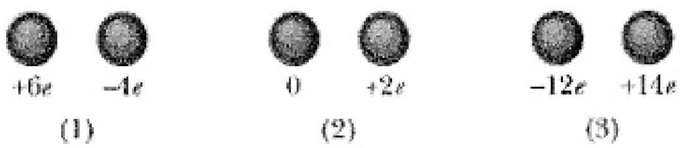
b) For isothermal $\Delta E = 0$ ∴ $|Q| = |W|$

$W = -4943$ J

$Q = -4943$ J (heat flows out)

Chapter 21

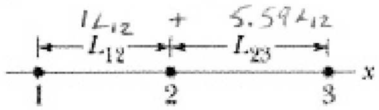
Q) Three pairs of identical spheres that are to be touched together and then separated. The initial charges on them are indicated. Rank the pairs according to (a) the magnitude of the charge transferred during touching and (b) the charge left on the positively charged sphere, greatest first.



a) To achieve same +2 final total, more charge must transfer in 3, then 1, then 2.

b) final net charge +2 total, shared equally, +1 on each remains, all tie

P) Particles 1 and 2 are fixed in place, but particle 3 is free to move. If the net electrostatic force on particle 3 due to particles 1 and 2 is zero and $L_{23} = 5.59L_{12}$, what is the ratio q_1/q_2?



$$F_3 = 0 = F_{13} + F_{23}$$

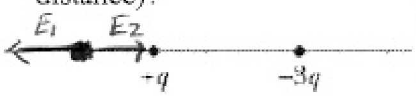
$$0 = \frac{kq_1q_3}{L_{13}^2} + \frac{kq_2q_3}{L_{23}^2}$$

-1.39

$$\frac{-kq_1q_3}{6.59L_{12}^2} = \frac{kq_2q_3}{5.59L_{12}^2} \longrightarrow q_1/q_2 = -\left(\frac{6.59}{5.59}\right)^2 = -1.39$$

Chapter 22

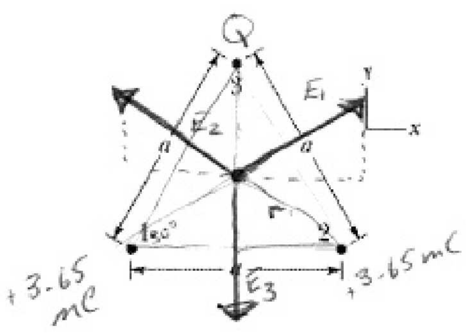
Q) Two charged particles fixed in place on an axis. (a) Where on the axis (other than at an infinite distance) is there a point at which their net electric field is zero: between the charges, to their left, or to their right? (b) Is there a point of zero net electric field anywhere *off* the axis (other than at an infinite distance)?



a) $E = \frac{kq}{r_1^2} - \frac{3q}{r_2^2} = 0$ when $r_1 < r_2$ so pt. is to left

b) Because of vector addition, cancellation only occurs on-axis.

P) Particle 1 (of charge +3.65 mC), particle 2 (of charge +3.65 mC), and particle 3 (of charge Q) form an equilateral triangle of edge length a. For what value (in C) of Q (both sign and magnitude) does the net electric field produced by the particles at the center of the triangle vanish?



$E_x = E_y = 0$ at center

$E_{1y} = E_{2y} = \frac{kq \sin 30°}{r}$ thus $E_{1y} + E_{2y} = +\frac{2kq_1}{r} \sin 30° = \frac{kq}{r}$

$E_{1x} = -E_{2y}$, Thus $E_{1x} + E_{2x} = 0$

Then for $E_x = E_y = 0$, $E_{3x} = 0$ and $E_{3y} = -\frac{2kq}{2r}$

0.00365 C

Thus at

$\frac{kq_3}{r} = E_{3y} = -\frac{kq_1}{r}$ Then $q_1 = q_3 = .00365$ C

Chapter 23

$\Phi_E = \int B \cdot dA = B \cdot A$

Q) A surface has the area vector $\vec{A} = (2\hat{i} + 3\hat{j})\mathrm{m}^2$. What is the flux of a uniform electric field through it if the field is (a) 4 **i** N/C and (b) 4 **k**? * Dot product multiplies parallel components

a) $2\hat{i} \cdot 4\hat{i} = \boxed{8 \frac{Nm^2}{C}}$ b) Ø (because ⊥)

P) A point charge $q = 1.0 \times 10^{-7}$ C is at the center of a spherical cavity of radius 1.9 cm in a chunk of metal. Use Gauss' law to find the magnitude of the electric field **(a)** 0.79 cm from the cavity center and **(b)** anyplace in the metal.

a) $E = \frac{kq}{r^2}$ from pt charge

$E = 1.44 \times 10^7$ N/C

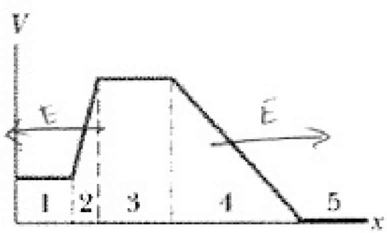
b) inside conductor E = Ø always in this case because free electrons are drawn to inner surface of cavity, gaussian surface in metal encloses Ø net charge

(a) 14000000 N/C

(b) 0 N/C

Chapter 24

Q) The figure below gives the electric potential V as a function of x. (a) Rank the five regions according to the magnitude of the x component of the electric field within them, greatest first. What is the direction of the field along the x axis in (b) region 2 and (c) region 4?

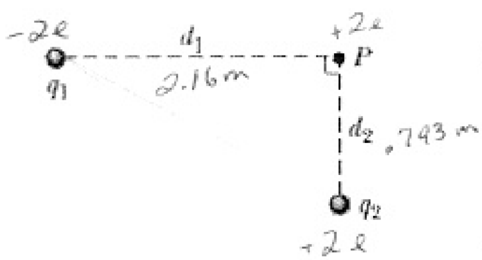


a) $E = -\frac{\Delta V}{\Delta s}$; Thus |slope| = |E|; 2, 4 1, 3, 5 (tied, E = 0)

b) left (neg)

c) Right (+)

P) Point P is at a distance $d_1 = 2.16$ m from particle 1 ($q_1 = -2e$) and distance $d_2 = 0.793$ m from particle 2 ($q_2 = +2e$), with both particles fixed in place. **(a)** With $V = 0$ at infinity, what is V at P? If we bring a particle of charge $q_3 = +2e$ from infinity to P, **(b)** how much work do we do and **(c)** what is the potential energy of the three-particle system?



a) $V = V_1 + V_2 = \frac{kq_1}{d_1} + \frac{kq_2}{d_2}$

$V_{TOT} = ke\left(\frac{-2}{2.16} + \frac{2}{.793}\right) = \boxed{2.30 \times 10^{-9} V}$ (e = 1.6E-19)

b) $|\Delta U| = |W|$ for 3rd charge

$qV = W = 2eV = \boxed{7.36 \times 10^{-28} J}$

c) $U_{tot} = U_{12} + U_{23} + U_{13}$

$= k\left(\frac{-4e^2}{\sqrt{d_1^2 + d_2^2}} + \frac{4e^2}{d_2} - \frac{4e^2}{d_1}\right)$

$-4.0 \times 10^{-28} + 11.6E\text{-}28 - 4.26E\text{-}28 = \boxed{+3.35 \times 10^{-28} J}$

(a) 2.30E-9 V

(b) 7.36E-28 J

(c) 3.35E-28 J

$i = \frac{V}{R}$ and $P = i^2 R$ → $P = \frac{V^2}{R}$

wire 1: $R = r$, $L = L$; wire 2: $R = 1.2r$, $L = 1.2L$; wire 3: $R = .9r$, $L = L$

Chapter 26

Q) Three wires, of the same diameter, are connected in turn between two points maintained at a constant potential difference. Their resistivities and lengths are r and *L* (wire *A*), 1.2r and 1.2*L* (wire *B*), and 0.9r and *L* (wire *C*). Rank the wires according to the rate at which energy is transferred to thermal energy, greatest first.

L doesn't matter, only V, i, R, Thus as $P = V^2/R$ (see above) Then $P_3 > P_1 > P_2$

P) A potential difference *V* is applied to a wire of cross sectional area *A*, length *L*, and resistivity ρ. You want to change the applied potential difference and stretch the wire so that the energy dissipation rate is multiplied by 34.0 and the current is multiplied by 3.55. Assuming the wire's density does not change, what are **(a)** the ratio of the new length to *L* and **(b)** the ratio of the new cross-sectional area to *A*?

$V_0 = i_0 R_0$; $P_0 = i_0^2 R_0$ while $R = \frac{\rho L}{A}$

then

(a) 1.64

(b) 0.609

$i_1 = 3.55 i_0$ and $P_1 = 34 P_0 = (3.55^2 i_0^2) R_1 = 34 i_0^2 R_0$ thus $\frac{R_1}{R_0} = 2.7 = \frac{\rho L_1 / A_1}{\rho L_0 / A_0}$

In stretching, Volume 0 = Volume 1 = A·L, thus $A_0 L_0 = A_1 L_1$

and subbing $A_0 = \frac{A_1 L_1}{L_0}$ Then $2.7 = \frac{A_1 L_1^2}{A_1 L_0^2}$ and $\frac{L_1}{L_0} = \sqrt{2.7} = 1.64$; $\frac{A_1}{A_0} = \frac{L_0}{L_1} = \frac{1}{1.64} = .6$

Chapter 27

Q) Initially, a single resistor R_1 is wired to a battery. Then resistor R_2 is added in parallel. Are (a) the potential difference across R_1 and (b) the current i_1 through R_1 now more than, less than, or the same as previously? (c) Is the equivalent resistance R_{12} of R_1 and R_2 more than, less than, or equal to R_1? (d) Is the total current through R_1 and R_2 together more than, less than, or equal to the current through R_1 previously?

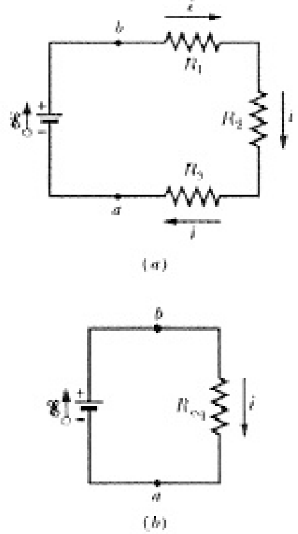
a) ΔV unchanged (= to battery ΔV)

b) Current $i = \Delta V / R_1$ is unchanged too.

c) R_{eq} is less $\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} < R_1$

d) total current = V/R_T = more

From the figure below, find the potential difference across R_2 if $\mathcal{E}$ = 15.8 V, R_1 = 2.14 Ω, R_2 = 4.46 Ω, and R_3 = 1.64 Ω.



$R_{Total} = 2.14 + 4.46 + 1.64\ \Omega = 8.24\ \Omega$ (series)

$V = iR$ and $i = \frac{V_{TOT}}{R_{TOT}} = \frac{15.8}{8.24\ \Omega} = 1.92$ Amps

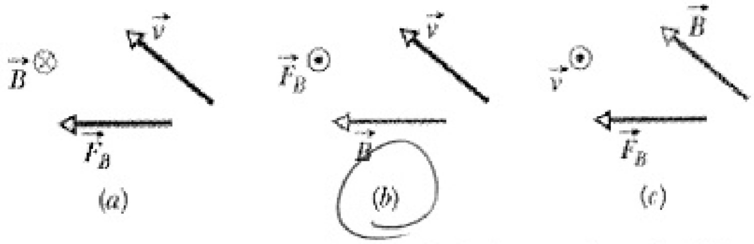
$\Delta V_{R_2} = i R_2 = 1.92 \times 4.46 = 8.55\ V$

8.55 V

Chapter 28

Q) Which of the following set of vectors are correct?

cross product, only b is correct



P) A particle moves along a circle in a region of uniform magnetic field of magnitude $B = 5.68$ mT. The particle is either a proton or an electron (you must decide which). It experiences a magnetic force of magnitude 1.81×10^{-15} N. What are **(a)** the particle's speed (in m/s), **(b)** the radius of the circle (in m), and **(c)** the period of the motion (in s)? The charge of an electron is -1.602×10^{-19} C and its mass is 9.109×10^{-31} kg. The charge of a proton is $+1.602 \times 10^{-19}$ C and its mass is 1.673×10^{-27} kg.

$F = 1.81E-15\,N = qvB$

(must be an electron by RHR)

a) $v = \frac{F}{qB} = 1.99 \times 10^6$ m/s

b) $\frac{mv^2}{r} = qvB$ so $r = \frac{mv}{qB} = 1.99 \times 10^{-3}$ m

c) $T = \frac{2\pi R}{v} = 6.29 \times 10^{-9}$ s

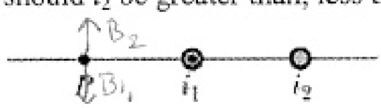
(a) 1990000 m/s

(b) 0.00199 m

(c) 6.29E-9 s

Chapter 29

Q) The figure below shows cross sections of two long straight wires; the left-hand wire carries current i_1 directly out of the page. If the net magnetic field due to the two currents is to be zero at point P, (a) should the direction of current i_2 in the right-hand wire be directly into or out of the page and (b) should i_2 be greater than, less than, or equal to i_1?



a) into

b) greater $\left(B = \frac{\mu_0 i}{2\pi R}\right)$

P) A cylindrical cable of radius 7.48 mm carries a current of 23.1 A, uniformly spread over its cross-sectional area. At what distance from the center of the wire is there a point within the wire where the magnetic field is 0.241 mT?

$B = \frac{\mu_0 i_{enc}}{2\pi r}$ where $\frac{i_{enc}}{i_{tot}} = \frac{\pi r^2}{\pi R^2}$ so $B = \frac{\mu_0 i_{tot} r}{2\pi R^2}$

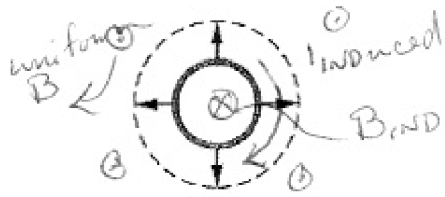
2.92 mm

Then $r = \frac{2\pi R^2 B}{\mu_0 i_{tot}} = 2.92 \times 10^{-3}$ m

Chapter 30

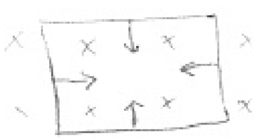
Q) If the circular conductor in the following figure undergoes thermal expansion while it is in a uniform magnetic field, a current is induced clockwise around it. Is the magnetic field directed into or out of the page?

* Induced field must oppose change in flux, by Lenz's Law.
* Since A is increasing, Flux is increasing
* Must be increasing out of page since induced is into page. ∴ B is uniform out



P) A square loop of wire is held in a uniform 0.19 T magnetic field directed perpendicular to the plane of the loop. The length of each side of the square is decreasing at a constant rate of 5.6 cm/s. What emf (in V) is induced in the loop when the length is 14 cm?

0.0030 V



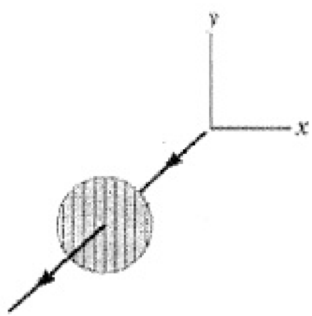
$B = .19$ $\mathcal{E} = \frac{d\Phi}{dt} = \frac{d\int B \cdot dA}{dt} = \frac{B\,dA}{dt}$ where $A = x^2$

$\mathcal{E} = B2x\frac{dx}{dt} = B2xv$

$\mathcal{E} = .0030\ V$

Chapter 33

Q) (a) The figure below shows light reaching a polarizing sheet whose polarizing direction is parallel to a *y* axis. We shall rotate the sheet 40° clockwise about the light's indicated line of travel. During this rotation, does the fraction of the initial light intensity passed by the sheet increase, decrease, or remain the same if the light is (a) initially unpolarized, (b) initially polarized parallel to the *x* axis, and (c) initially polarized parallel to the *y* axis?



a) same ($I = \frac{1}{2} I_0$ no matter what)

b) increase (from zero to some)

c) decrease (from all to less)

P) Light in vacuum is incident on the surface of a slab of transparent material. In the vacuum the beam makes an angle of 45.7° with the normal to the surface, while in the slab it makes an angle of 27.9° with the normal. What is the index of refraction of the transparent material?

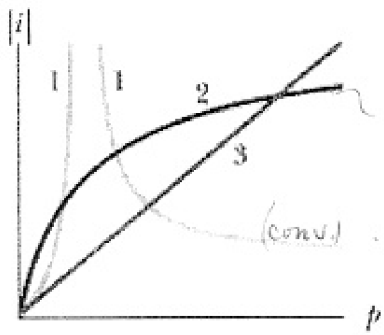
1.53

$n_1 \sin\Theta_1 = n_2 \sin\Theta_2$ $n_1 = 1$ for vacuum

$n_2 = \frac{\sin\Theta_1}{\sin\Theta_2} = 1.53$

Chapter 34

Q) An object is placed against the center of a converging lens and then moved along the central axis until it is 5.0 m from the lens. During the motion, the distance $|i|$ between the lens and the image it produces is measured. The procedure is then repeated with a diverging lens. Which of the curves on the plot best gives $|i|$ versus the object distance p for these lenses? (Curve 1 consists of two segments. Curve 3 is straight.)



a) $\frac{1}{f} = \frac{1}{p} + \frac{1}{i}$ all pos. when i real; when $p = f$, $i \to \infty$, so this must be #1

b) $-\frac{1}{f} = \frac{1}{p} + \frac{1}{-i}$ (i and f always neg.) so $\frac{1}{p} = \frac{1}{i} - \frac{1}{f}$ and $\frac{1}{i} = \frac{1}{p} + \frac{1}{f} = \frac{f+p}{pf}$, then $i = \frac{pf}{f+p}$ (which is not …) must be …

P) A small cup of green tea is positioned on the central axis of a spherical mirror. The lateral magnification of the cup is +0.245, and the distance between the mirror and its focal point is 3.15 cm. What is the distance between the mirror and the image it produces?

| 2.38 | cm

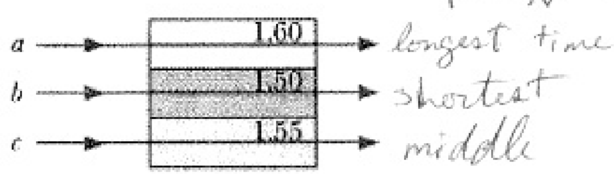
$m = \frac{h'}{h} = .245 = \frac{-i}{p}$ so $i = -.245p$

$\frac{1}{-i} + \frac{1}{p} = \frac{1}{f}$ then $p = 9.7$ cm if $f = -3.15$ cm (mirror must be convex or p comes out neg. which is not allowed). Then $i = \left(-\frac{1}{3.15} - \frac{1}{9.7}\right)^{-1} = 2.38$ cm

Chapter 35

Q) In the figure, three pulses of light—*a*, *b*, and *c*—of the same wavelength are sent through layers of plastic having the given indexes of refraction. Rank the pulses according to their travel time through the plastic, greatest first.

$t = L/v$ and $n = c/v$ so $v = c/n$ then $t = \frac{Ln}{c}$



P) A thin film suspended in air is 0.400 μm thick and is illuminated with white light incident perpendicularly on its surface. The index of refraction of the film is 1.60. At what wavelength will visible light that is reflected from the two surfaces of the film undergo fully constructive interference?

512 nm

X not covered → focus on Ch. 35, #19 from Wiley and double-slit examples in text

Chapter 36 $d\sin\theta = m\lambda$ $v = \lambda f$

Q) Light of frequency *f* illuminating a long narrow slit produces a diffraction pattern. (a) If we switch to light of frequency 1.3*f*, does the pattern expand away from the center or contract toward the center? (b) Does the pattern expand or contract if, instead, we submerge the equipment in clear corn syrup?

a) If f ↑, Then λ is ↓ therefore θ is smaller and fringes contract

b) If everything is in corn syrup ($n > 1$) then $\lambda = \lambda/n$ which is smaller so θ also smaller and the fringes again contract.

X

P) The pupil of a person's eye has a diameter of 5.00 mm. According to Rayleigh's criterion, what distance apart must two small objects be if their images are just barely resolved when they are 250 mm from the eye? Assume they are illuminated with light of wavelength 500 nm.

30.5 μm

not covered, no problems from Ch. 36 will be included