PHYS 2426 Sizemore’s Practice Exam Questions

* 50 point exam
* Use the SOLVE method (where applicable)
* To receive full credit you must **show all your work** (for example, 5 step problem solving method).
* 4x6 card or ¼ of 8 ½ in by 11 in note page written on both sides allowed
* Please be neat, logical and organized.
* Quizzes and exams have room to show work and you may staple extra pages on exam.
* Partial credit is awarded for correct work shown.
* Round and estimate answers – this is a self-diagnosis and beneficial for you.
* Be careful about units, unit conversions, and dimensional analysis – this is also self-diagnosis and beneficial for you.
* Calculators are allowed.
* Unless otherwise stated, show 3 or more significant digits for precise answers.
* Point value is approximate time in minutes required to complete problem for most students who know and understand the material. Good students should be able to complete these problems much faster, but enough time is allotted for all students to complete the work.

Table of Metric Prefixes

|  |  |  |  |
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| Prefix | Abbreviation | Numeric Value | Example |
| femto | f | 10-15 | fm = 10-15 m – about size of atom’s nucleus |
| pico | p | 10-12 | pf = 10-12 f – a common value of capacitance |
| nano | n | 10-9 | nm = 10-9 m – common unit for wavelength of visible light |
| micro |  | 10-6 | m = 10-6 m – about size of bacteria |
| milli | m | 10-3 = 1/1000 | mm = 10-3 m – smallest division on common metric ruler |
| centi | c | 10-2 = 1/100 | cm = 0.01 m |
| kilo | k | 103 = 1000 | kg = 1000 grams |
| Mega | M | 106 | MHz = 103 HZ – about the center of the AM radio frequency band |
| Giga | G | 109 | Gbyte = 103 byte – common unit of computer memory |
| Tera | T | 1012 | Tbyte = 1012 – common unit of hard disc memory |
| Peta | P | 1015 | Pbyte = 1015 – about memory size of human brain |

**Halliday & Resnick Chapters 21-27**

1. 25 Points: You are given resistors and capacitors R1 = 16  R2 = 56  R3 = 12 C1 = 16 F, C2 = 56 F, and C3 = 12 F.

R1

R3

R2

C1

C3

C2

* 1. What is the resistance of the resistor network?
  2. What is the capacitance of the capacitor network?
  3. What is time constant for the series connection of R1 and C1?
  4. For Parts (f) through (j), capacitor C1 is charged to 18 V. What is the starting charge on C1?
  5. How much energy is stored by capacitor C1?
  6. When capacitor C1 is discharged through R1, what is the starting current flow through R1?
  7. How much power is dissipated by R1?
  8. How long does it require for capacitor C1 to discharge through R1 to 70% of its starting value?
  9. What is the current flow through R1 when the voltage across C1 has dropped to 70% of the starting value?

1. 15 Points: Two charges (q1 = -2 nCoul and q2 = ‑1 nCoul) are separated by 0.4 m. Recall k = 8.99\*109 N m2 / coul2 and n = nano = 10-9.

0.4 m

q1

q2

0.4 m

B

C

* 1. What is the electric field, including direction, at Point C (to the right of q1)?
  2. What is the force on a test charge of 1 pCoul (10-12 C) at Point C?
  3. What is the voltage at Point C?
  4. What is the work required to move a test charge of 1 pCoul from infinitely far away to Point C?

1. 10 Points: A coax cable is comprised of an inner metal cylinder 1 mm in outer diameter with 4 mm of insulator followed by a metal outer cylinder (inner diameter of outer metal cylinder is 5 mm). The axes of the cylinders are common (thus the name coaxial cable), consider the system to be infintely long, and the outer cylinder zero thickness. Total charge is zero and charge per length on the outer metal shell is 1 nC/m. k = 8.99\*109 N m2/Coul2 and o = 8.85\*10-12 Coul2/(N m2).
   1. Use Gauss’ Law to sketch the electrical field as a function of radius (distance from center axis).
   2. What is the electric field on the surface of the inner conductor?
   3. What is the electric field on the surface of the outer conductor?
   4. What is the voltage difference between the inner and outer conductor.

**Halliday & Resnick Chapters 28-31**

1. 20 Points: A series RLC circuit is driven at 300 kHz with VRMS = 18 V and has components R = 9 , L = 37 H, and C = 8000 pF. Recall c = 3\*108 m/sec. Answer the following:
   1. What is the impedance?
   2. What is the phase angle?
   3. What is the power factor?
   4. What is the average power dissipated?
   5. Draw a rough sketch of the phase diagram (using phasors)?
   6. What is the resonance frequency?
   7. What is the maximum energy stored in the inductor?
   8. What is the maximum energy stored in the capacitor?
2. 20 Points: A toroid with 90 cm inner radius and 110 cm outer radius and 10,000 loops carries a current of 2 A. A wire 1 cm long carries a current, I, of 4 A at the inside middle of the toroid (in other words, 100 cm from the center). Recall a toroid is a donut shaped object where the donut hole has a 90 cm radius from the center of the donut and the outside of the donut has 110 cm radius. Also recall o = 4\*10‑7 T m/A

I

B

* 1. Derive a formula using Ampere’s Law for the magnetic field *generated by the toroid 100 cm from the center.* Draw a sketch properly indicating directions using the right hand rule and direction of electron flow through the wires.
  2. Use the Biot-Savart Law to compute the magnetic field generated by one coil of this toroid. Think of this as calculating the magnetic field at the center of a 20 cm diameter coil carrying 2 A. Draw a sketch properly indicating directions using the right hand rule and direction of electron flow through the wires. Comment on both the magnitude and direction of this result compared to the answer from Part (a).
  3. What is the force on this length of short wire inside the toroid if the length of the wire is perpendicular to the magnetic field? You may consider the wire to be very short compared to the size of the toroid, however extra credit will be granted for finding an exact solution. You may represent the magnetic field acting on the short wire as a single arrow, however sketch the remainder of this problem using the right hand rule and showing the direction of electron flow through the wire.
  4. Now instead of a single 1 cm length of wire, consider a single square loop of wire 1 cm on a side carrying the same current. Calculate the maximum torque and angle when maximum torque occurs on this loop.
  5. What is the maximum work it requires to rotate the coil in Part (d) from one orientation to another and what angles would you rotate this coil through? Include a sketch with this problem.
  6. If the current in the toroid varies sinusoidally, what is the maximum EMF generated in the coil?

1. 10 Points: A transformer with 9,600 loops on the primary and 21,000 loops on the secondary has an input of 5300 V at 0.8 A.
   1. What is output voltage?
   2. What is ideal output current?
   3. If efficiency is 61%, what must the input current be?
   4. What is the effective resistance the primary sees if the load on the secondary is 8 Ω?

**Halliday & Resnick Chapters 32-36**

1. 10 Points: A typical consumer microscope has an objective of focal length 24 mm, a 16 mm focal length eyepiece, distance between lenses of 320 mm, and use near point distance = N = 400 mm.
2. Draw a ray diagram?
3. What is the magnification?
4. For ordinary crown glass (n = 1.5), what is the radius of curvature of one curved side of the objective lens if the other side is flat?
5. Reflecting lenses can be used as objectives in microscopes. For a reflecting objective lens, what is the radius of curvature?
6. 10 Points: 357 nm light enters the hypotenuse of a 30-60-90 prism of ordinary crown glass (index of refraction is 1.5) and exits the side adjacent to the 30° angle (see figure). Recall c = 3\*108 m/sec.

30°

* 1. What must be the exit angle (inside the prism) for total internal reflection at the glass-to-air exit interface?
  2. What is the entrance angle inside the glass at the light beam entrance air-to-glass interface? Hint: Once you know the answer to Part (a), it is a matter only of geometry to find the angle of refraction as the light enters the prism.
  3. What is the speed of light inside the glass?
  4. How thick and at what index of refraction would an antireflective coating need to be?
  5. What is the Brewster angle?

1. 20 Points: Spacing between slits of a diffraction grating is 1.5 m and the incident light is reading laser has a wavelength of 590 nm.
2. List all the angle of the interference fringes?
3. How many orders of interference fringes are produced?
4. If there are only two infinitesimally small slits (intensity on one opening is Io), what is the ratio of intensity at the first order of diffraction to intensity at the center?
5. If the slits are 0.2 m wide, what is the ratio of intensity (at the first order) to the intensity at the center?
6. For a grating with 10 openings, what is the half width of the first order diffraction spot?
7. What is the dispersion for the grating of part (e)?
8. What is the resolving power?
9. The 100 plane in BCC iron has a spacing of 0.143 nm. What is the maximum x-ray wavelength to achieve diffraction from this plane of this crystal?
10. 5 Points: A polarizer is used to analyze linearly polarized light and is at 19° to the polarization of the incident light. What is the percentage of light transmitted?
11. 5 Points: Answer the following for a converging lens with an object distance of 12 cm and *virtual* image distance of 46 cm.
12. What is the focal length?
13. What is the magnification?
14. For a spherical mirror, what is the radius of curvature?
15. For a lens curved on both sides with equal radii and n=1.5, what is the radius of curvature?
16. 10 Points: Light spherically radiates with intensity 0.84 W/m2 at a distance of 2.1 m. Recall c = 3\*10-8 m/s, o = 4\*10-7 T m/A, and o = 8.85\*10-12 Coul2/N m2.
17. What is Erms?
18. What is Brms?
19. What is the light pressure for complete reflection?
20. What is the light pressure for complete absorption?
21. What is the intensity at 5.0 m?