

Your Name:

Instructions

Solve each of the following problems to the best of your abilities. I will give partial credit for solutions, so show all of your work. Solutions with no work will not receive any credit.

You are allowed four 8 1/2 by 11" sheets of paper for notes as well as a calculator to aid you on the test. I can also provide you with some extra sheets of blank paper if needed.

The exam is calibrated for around 90 minutes, but you have the full class period. Once you have completed the exam, hand it to me and then you are free to leave. Good luck!

(4 points) Two point charges, each with a charge of $+1.0 \text{ mC}$, are separated by a distance of 0.15 m .

- What is the magnitude of the electric force between the point charges?
- Do they attract each other or repel each other?

400,000 N, they repel

(4 points) What is the difference between an electric conductor versus an electric insulator?

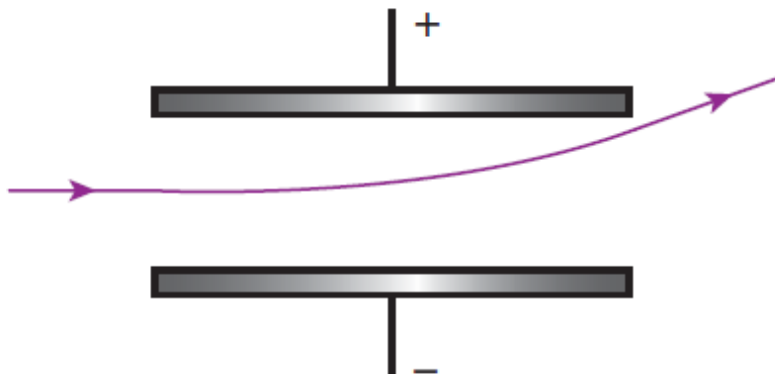
Conductors allow charge to flow within them whereas an insulator does not.

(8 points) A ball is charged with a net positive charge. Create a sketch of the ball in the space below.

- Draw and label the electric fields vectors around the ball (remember, the direction of the vectors matters).
- Draw and label the electric potential lines around the ball.

(4 points) What is the principle of superposition?

(2 points) A beam of electrons is deflected as it moves between two charged parallel plates according to the diagram below. Which plate is at the higher electric potential (the top plate or the bottom plate)?



Top plate

(4 points) A chunk of material stores a charge of 0.10 C when a voltage of 12 V is connected to it. What is its capacitance?

$$0.08333 \text{ F} = 83.3 \text{ mF}$$

(4 points) Why might we use a dielectric substance in between the plates of a parallel plate capacitor?

(4 points) Three resistors, each with a resistance of 60Ω , are connected in series along with a battery of voltage 12 V. What is the current drawn from the battery?

$$R_{tot} = 180 \Omega$$

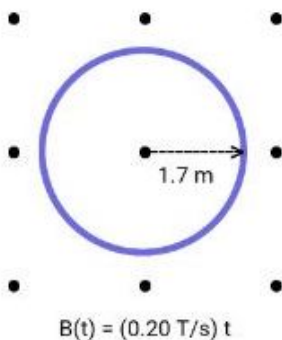
$$I_{tot} = 0.06667 \text{ A} = 66.7 \text{ mA}$$

(4 points) A positively charged particle is fired into a magnetic field with an initial velocity in the $+\hat{z}$ direction. If the magnetic field is pointing in the $-\hat{y}$ direction, in which direction is the initial force on the particle?

$+\hat{x}$

(4 points) What is a velocity selector? Why is it useful?

(2 points) The magnetic field in the diagram is pointing out of the page and increasing in magnitude. Is the current in the loop of wire clockwise or counterclockwise?



Clockwise

(4 points) What is Lenz's law? Why is it important in the context of Faraday's law of induction?

(4 points) A charging LR circuit consists of a battery (10 V), a resistor (100 Ω), and an inductor (0.5 H) in series. What is the time constant of the circuit?

$$L/R = 0.005 \text{ sec}$$

(4 points) An AC RLC circuit is made up of a 10 ohm resistor, a 1.5 mF capacitor, and a 1.8 mH inductor. What is the resonant frequency of the circuit?

608.6 Hz

(4 points) A supernova is an exploding star that is billions of times brighter than an ordinary star. Supernova SN1987a occurred 1.6×10^{21} m from Earth. How long did it take light to travel from the supernova to Earth?

$$5.33 \times 10^{12} \text{ sec} \approx 169,013 \text{ years}$$

(4 points) What is the Doppler effect? How does the Doppler effect affect EM waves?

(4 points) Light from a laser pointer is coherent whereas light from a flashlight is incoherent. What does it mean for light to be coherent versus incoherent?

(4 points) What is an index of refraction? Where might it be used in the study of optics?

(4 points) What is an "electron volt"?

(4 points) What is an "inertial" reference frame?

(4 points) A spaceship with a mass of 2.0×10^4 kg is traveling with a speed of 0.75c. What is the relativistic kinetic energy of the spaceship?

9.21e20 J

(4 points) The fastest fighter jet ever created was the NASA/USAF X-15. It was an experimental aircraft that resembled a rocket with wings and reached a record 4,520 mph (about 2,020 m/s). Would a casual observer on Earth see the jet length contracted as it zoomed by without the use of any special equipment? Why or why not?

(4 points) How does the famous formula $E = mc^2$ relate to the binding energy of nucleons?

57 138.90... La Lanthanum Lanthanide	58 140.116 Ce Cerium Lanthanide	59 140.9... Pr Praseody... Lanthanide	60 144.24 Nd Neodymium Lanthanide	61 144.91... Pm Promethium Lanthanide	62 150.4 Sm Samarium Lanthanide	63 151.964 Eu Europium Lanthanide	64 157.2 Gd Gadolinium Lanthanide	65 158.9... Tb Terbium Lanthanide	66 162.500 Dy Dysprosium Lanthanide	67 164.93... Ho Holmium Lanthanide	68 167.26 Er Erbium Lanthanide	69 168.9... Tm Thulium Lanthanide	70 173.05 Yb Ytterbium Lanthanide	71 174.96... Lu Lutetium Lanthanide
89 227.0... Ac Actinium Actinide	90 232.038 Th Thorium Actinide	91 231.03... Pa Protactinium Actinide	92 238.0... U Uranium Actinide	93 237.0... Np Neptunium Actinide	94 244.0... Pu Plutonium Actinide	95 243.0... Am Americium Actinide	96 247.07... Cm Curium Actinide	97 247.07... Bk Berkelium Actinide	98 251.07... Cf Californium Actinide	99 252.0... Es Einsteinium Actinide	100 257... Fm Fermium Actinide	101 258... Md Mendelevi... Actinide	102 259... No Nobelium Actinide	103 266... Lr Lawrencium Actinide

(4 points) A U-238 nucleus (Uranium) can decay by emitting an alpha particle. What element will it transform into? You can use the snippet of the periodic table above as a reference.

Thorium

(4 points) The primary decay mode of Eu-146 (Europium) is β^+ decay. What element is produced after Europium goes through this decay process? You can use the snippet of the periodic table above as a reference.

Samarium