

Final Exam

Your Name:

Instructions

Answer each of the following questions to the best of your ability. The exam is worth 100 points total and is calibrated for 120 minutes. Please show all of your work to receive full credit.

Once you have completed the exam, you are free to leave. Have a great rest of your summer!

1. Two point charges, each with a charge of $+0.1 \text{ mC}$, are separated by a distance of 2.5 m . What is the electric force between the particles? Do they attract or repel?
2. Sketch a diagram showing the electric field lines and equipotential lines between the plates of an ideal parallel plate capacitor. Be sure to label the field lines and the equipotential lines.
3. Two point charges, each with a charge of -2.0 mC , are separated by a distance of 0.4 m . What is the electric potential energy of the system?
4. A chunk of material stores 0.2 mC of charge when it is connected to a potential difference of 12 V . What is the capacitance of the metal chunk?
5. Two $20 \text{ } \Omega$ resistors and a battery with voltage 15 V are all connected in parallel. What is the total power generated by the battery in this circuit?
6. A negatively charged particle is fired into a magnetic field with an initial velocity in the $+z$ direction. If the magnetic field is pointing in the $-x$ direction, in which direction is the initial force on the particle?
7. Sketch the magnetic field lines around a bar magnet. Be sure to label the north and south poles.
8. I want to build a velocity selector that is calibrated to let particles with a speed of 1000 m/s through, undeflected. What magnitude of electric field should I use if I am using a magnetic field of 0.2 T ?
9. A charging DC LR circuit consists of a battery (15 V), a resistor ($160 \text{ } \Omega$), and an inductor (0.5 H) in series. What is the time constant of the circuit?
10. What is the difference between a paramagnetic material and a ferromagnetic material?

11. The magnetic flux passing through a single turn loop of wire is given by $\phi_B(t) = 10 t^2 \text{ Wb}$. What is the induced EMF in the loop at time $t = 2$ seconds (including the correct sign)?
12. What is the RMS voltage of a square wave with an amplitude of 10 V?
13. An AC RLC circuit is made up of a 10-ohm resistor, a 130 mF capacitor, and a 1 H inductor. What is the resonant frequency of the circuit?
14. A step-up transformer has a turn ratio of $N_2/N_1 = 100$. If I apply a 12-volt RMS AC voltage to the input of the transformer, what is the RMS output voltage?
15. What is the phase angle of a series RLC AC circuit when it is driven at resonance?
16. What is the difference between “self-inductance” and “mutual-inductance”?
17. In the context of the Ampere-Maxwell equation, how is displacement current different from “regular” current?
18. An electromagnetic wave has an electric field aligned along the y-axis and travels in the +z direction. What is the direction of the Poynting vector of the wave?
19. Light, initially polarized along the z-axis, encounters a polarizing filter at 15 degrees with respect to the z-axis. What percentage of light passes through the filter?
20. What is Huygen’s Principle?
21. How is the speed of a wave of light in a vacuum different than other waves? How did we come to this conclusion?
22. A ray of light with a wavelength of 450 nm passes from air ($n = 1.00$) to crown glass ($n = 1.55$). Calculate the angle of reflection if the angle of incidence of the ray of light is 21 degrees.

23. A ray of light with a wavelength of 850 nm passes from air ($n = 1.00$) to water ($n = 1.33$). Calculate the angle of refraction if the angle of incidence of the ray of light is 35 degrees.
24. What is the critical angle of light between amber ($n = 1.55$) and benzene ($n = 1.501$)?
25. An object with a height of 10 cm is located 40 cm in front of a plane mirror. Where is the image located?
26. An object with a height of 15 cm is located 20 cm in front of a converging mirror with a focal length of $|f| = 5$ cm. Where is the image located?
27. An object with a height of 10 cm is located 25 cm in front of a diverging lens with a focal length of $|f| = 15$ cm. What is the final height of the image?
28. What is chromatic aberration in the context of mirrors?
29. The index of refraction of fused silica is around 1.51. What is the wavelength of red light (700 nm in vacuum) as it passes through the material?
30. A double slit interference apparatus has a slit separation of 0.4 mm. At what angle would we see the 8th order maximum if we shine light with a wavelength of 500 nm on it?
31. A thin film of soapy water ($n = 1.33$) is sandwiched between layers of air in a soap bubble. At what minimum thickness of the film would I see red light with a wavelength of 760 nm?
32. In class, we went through a derivation of the equation for electromagnetic waves, starting from Maxwell's equations. What do we mean by the "curl" and "divergence" of a vector field? You do not have to show any mathematics – an explanation will suffice.