July 22th 2024 | European Summer Programm | First name :

Physics II (part 2)

Duration : 2h | **Final exam** | Last name :

Formula sheet and calculator allowed - No phone -

If you believe there is an error in the provided multiple-choice answers, feel free to write down your own answer.

Constant values : $\mu_0 = 4\pi \times 10^{-7}\, H/m$; $\epsilon_0 = 8.85 \times 10^{-12} F/m$ and $c = 3 \times 10^8\, m.s^{-1}$

Chapter 31 – EM oscillations and alternating current

Problem 1 (6pt)- A series RLC circuit has a resistance $R = 75\,\Omega$, an inductance $L = 0.25\,H$, and a capacitance $C = 100\,\mu F$. The circuit is driven by an AC voltage source $V(t) = 150\sin(500\,t)$ (in Volt)

1) What is the resonant angular frequency ω_0 of the circuit?

A – ~ 0.01	B - ~ 200	C – ~ 40 000	unit?	rad/s
D – ~ 500	E – ~ 20 000	F – ~ 3 141		Hz

2) Is this RLC circuit at resonance?

A – *Yes*	Why?
C – *No*	

3) Calculate the total impedance of the circuit

A – ~ 129	B - ~ 785	unit?	Z	Ω
C – ~ 145	D – ~ 163		Hz	Has no unit

4) Calculate the phase angle ϕ

A – ~ 59°	B – 0°	C – ~ 54°
D – ~ − 23°	E – ~ − 151°	F – ~ 5.8°

5) Calculate the RMS current I_{rms}

A – ~ 1.16 A	B - ~ 2 A	C – ~ 0.741 A
D – ~ 0.822 A	E – ~ 1.41 A	F – ~ 132 mA

6) Calculate the average power dissipated in the circuit

A – ~ 73 W	B – ~ 101 W	C – ~ 51 W
D – ~ 21 W	E – ~ 174 W	F – ~ 87 W

Problem 2 (2pt)- A step-up transformer is used to increase the rms voltage from 230 V (primary) to 11 kV (secondary). The initial input power is 150kW.

1) Calculate the turns ratio between the primary and secondary winding of this transformer.

A – $\frac{N_s}{N_p} = 0.021$	B – $\frac{N_s}{N_p} = 33.8$
D – $\frac{N_s}{N_p} = 47.8$	E – $\frac{N_s}{N_p} = 150$

2) If a transmission line is connected to the secondary winding with a resistance of 25Ω, what power will be lost on the transmission line?

A – 3136 W	B – 8500 W
C – $1.06 \times 10^7\, W$	D – 4.6 kW

Chapter 33 – Electromagnetics waves

Problem 1 (4pt)- The electric field part of an electromagnetic wave in a medium (not necessarily vacuum) is represented by:

$$\begin{cases} E_x = 0 \\ E_y = 2.4\sin(2\pi \times 10^6\, t - \pi \times 10^{-2}\, x) \\ E_z = 0 \end{cases}$$

1) What is the frequency of this EM wave?

A – $2\pi \times 10^6\, Hz$	B – 10^6 Hz
C – $\sim \pi \times 10^{-2}$	D – ~ 2.4

2) Calculate its wavelength

A – $0.005\, m$	B – $10^{-2}\, m$
C – $32\, m$	D – $200\, m$

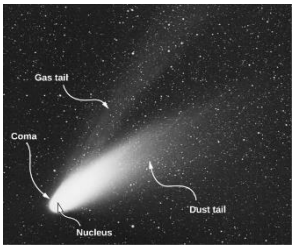
3) This EM wave is moving along the

A – *x direction*	B – *y direction*
C – *z direction*	D – *one direction*

4) What is the magnetic strength of the EM wave?

A – 2.4×10^{-6}	B - 7.2×10^8	Unit?	V/m	T
C – 8×10^{-9}	D – 6.1×10^6		$N.C$	V

Problem 2 (3pt)- On February 9, 1986, Comet Halley was at its closest point to the Sun, about $9.0 \times 10^{10} m$ from the center of the Sun. The average power output of the Sun is $3.8 \times 10^{26}\, W$.



1) Calculate the intensity of the solar radiation received by the comet at this point in its orbit.

A – $\sim 3.73 \times 10^3$	B - $\sim 1.07 \times 10^{17}$	Unit?	W	N
C – $\sim 4.69 \times 10^4$	D – $\sim 8.42 \times 10^{-4}$		$J.s$	W/m²

2) Assuming that the comet reflects all the incident light, calculate the the radiation pressure on the comet.

A – $\sim 1.24 \times 10^{-5}$	B - $\sim 2.49 \times 10^{-5}$	Unit?	W	N
C – $\sim 7.9 \times 10^{-6}$	D – $\sim 4 \times 10^{-12}$		N/m^2	W/m²

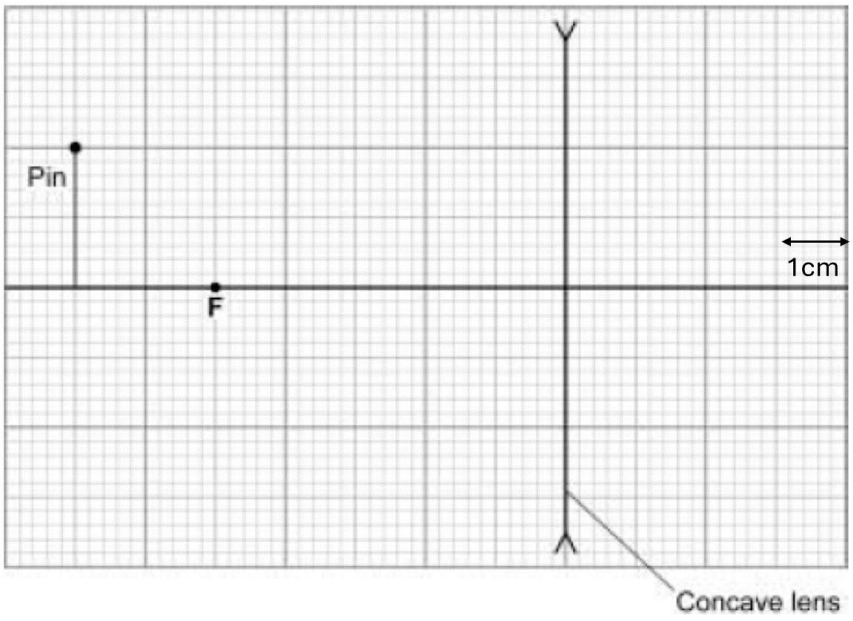
Bonus question (+1pt)– The condition under which a microwave oven heats up food item containing water molecules most efficiently is

A – The frequency of the microwave must match the resonant frequency of the water molecules	B – The frequency of the microwaves has no relation with the natural frequency of water molecules
C – Microwaves are heat waves, so always produce heating	D – Infra-red waves produce heating in microwave oven

Chapter 34 – Geometrical Optics

Problem 1 (4pt)–

1) Complete the ray diagrams below to show how the image of the pin is formed by this diverging lens. Use only two particular rays.



2) Using the grid of the ray diagram above, measure the algebraic value of the position p of the object, the algebraic value position i of the image and the magnification m.

$p =$	$i =$	$m =$

3) This image is (*choose the two correct options from the following list*):

A– real	B– virtual

and

C– inversed	D– not inversed

Problem 2 (2pt)- Rohit makes his girlfriend a romantic candlelight dinner and tops it off with a dessert of gelatin filled with blueberries. If a blueberry that appears at an angle of 44.0° to the normal in air is really located at 30.0° to the normal in the gelatin, what is the index of refraction of the gelatin?

$n_{gel} =$

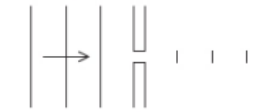
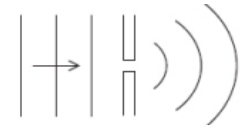
Problem 3 (2pt) – Binoculars contain prisms inside that reflect light entering at an angle larger than the critical angle. If the index of refraction of a glass prism is 1.58, what is the critical angle for light entering the prism?

$\theta_c =$

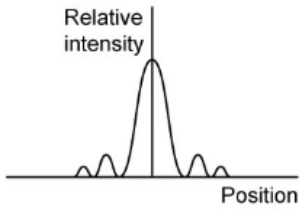
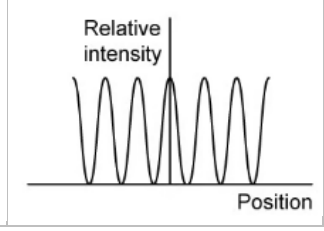
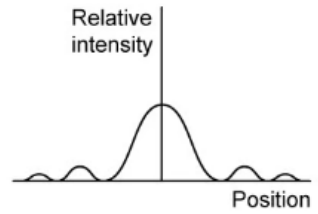
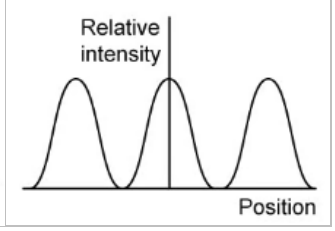
Chapters 35-36 – Interference and diffraction

MCQ (3.5pt)–

1) Plane wavefronts pass through a gap in a barrier. The gap is much smaller than the wavelength of the wave. Which diagram best shows the resultant shape of the wavefronts?

A–	B–	C–	D–
			

2) Light of the same wavelength is incident on a single slit. The width of the slit is changed. A **diffraction pattern** for each slit width is observed on a screen some distance away. Which pattern represents that of the narrowest slit?

A–	B–	C–	D–
			

3) Monochromatic light from a laser passes through two slits separated by $0.005\,mm$. The third bright line on a screen is formed at an angle of 18.0° relative to the incident beam. What is the wavelength of the light?

A– 51.5 nm	B– 77.3 nm
C– 515 nm	D– 773 nm

Problem (2.5pt)– You can measure the diameter of a human hair by performing a simple diffraction experiment. This method is similar to measuring the spacing of an aperture in a single slit diffraction experiment. Here's how you can do it at home:

- Tape a single human hair vertically across the center of a laser pointer's aperture.
- Shine the laser through the hair onto a screen or wall placed at a known distance L from the hair.
- Observe the diffraction pattern formed on the screen. You should see a central bright fringe and several dimmer fringes on either side.
- Measure the distance y between the central bright fringe and the first-order dark fringe on one side.

1) In a single-slit diffraction experiment, the first minimum occurs when:

A– $sin\,\theta = \frac{m\lambda}{a}$	B– $sin\,\theta = \frac{\lambda}{a}$
C– $sin\theta = \frac{2\lambda}{a}$	D– $sin\,\theta = \frac{\lambda}{2a}$

2) Assume the wavelength of the laser pointer is $\lambda = 650\,nm$ (red laser), the distance from the hair to the screen is $L = 1.0\,m$, and the distance from the central maximum to the first minimum is $y = 11\,mm$. What is the width a of this hair?

One of the most favorite trick of physicist is to assume that for small angles, $\boldsymbol{\theta \approx sin\theta \approx tan\theta = y/L}$*, where y is the distance from the central maximum to the first minimum, and L is the distance from the hair to the screen.*

$a \approx$