



Summer Course "Vibrations & waves" (212 P)

Answer only Five Questions:

- 1.a) Find the resonance frequency of LRC -circuit, compare the resulting eqn. with that obtained in LC -circuit.
b) Apply the propagation wave eqn. in one dimension: $Y = f(x - ut)$ to find the corresponding eqn. in terms of wavelength.

- 2.a) Explain the physical significance of the restoring force in the following oscillations: (i) vibration of a liquid in U-tube
(i) Vibration of a mass tied at the middle of string. (iii) Rotation vibration of a cylinder around its axis.
b) Use the general eqn. of vibrating n^{th} - symmetric mass: $\omega_s = \omega_0^2 [1 - \cos(s\pi / n + 1)]$ to study the vibrations of six masses.

- 3.a) Compare between the mechanical and electrical parameters of the forced damped oscillations. Determine the average power dissipated by fraction in the forced mechanical damped oscillator in terms of the damping parameter (b).
b) Considering that: $y = A \cos(t - x\mu / C)$ is the displacement of the propagation wave in one dimension, find the corresponding eqn. for an absorbed medium. Explain the physical significance.

- 4.a) Let $F_0 \exp(i\omega x)$ is the force acts on a tense string at a certain position ($x = 0$) of its length, find the displacement eqns. of different waves. Discuss the physical conditions required for obtaining the reflectance and transmittance coefficients.
b) Illustrate with the eqns. that the phase difference in the LRC circuit could be given by: $\theta = \tan^{-1}[(\omega L - 1 / \omega C) / R]$ where ω is the angular frequency of the damping force.

5. a) Consider: $I = A' \exp(i\omega x)$ represents the flowing current through LRC circuit, rewrite an expression of the current eqn. in terms of the distortion factor. Explain the physical significance.
b) The energy of a damped harmonic oscillator is observed to reduce by a factor of 2 after 10 complete cycles, by what factor will it reduces after 50 complete cycles

- 6.a) A sound wave propagate from a movable source, Prove that the max. of the difference between the real and virtual frequencies of the source: $(\nu' - \nu)_{\text{max.}} = [\nu \nu_s / (\nu - \nu_s)]$, where ν_s is the velocity of the fixed observer.
b) A source emits two alarms the difference between its frequency is 320 HZ, if the source moving with velocity (36 Km/hr) calculate the corresponding virtual difference of the two frequencies (sound wave 330 Km/hr).

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انتهت الأسئلة

- b- A light source of wavelength λ illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.00 eV. A second light source with half the wavelength of the first ejects photoelectrons with a maximum kinetic energy of 4.00 eV. Determine the work function of the metal. (5 Mark)

- c- Derive the relation between the electron's de Broglie wavelength and the circumference of Bohr's circular orbit. (5 Mark)

Electron charge e	$1.6 \times 10^{-19} \text{ C}$	Plank's constant h	$6.626 \times 10^{-34} \text{ Joule.sec}$
Electron mass m_e	$9.1 \times 10^{-31} \text{ kg}$	Light velocity c	$3 \times 10^8 \text{ m.sec}^{-1}$
Proton mass m_p	$1.672 \times 10^{-27} \text{ kg}$	Coulomb constant k	$9 \times 10^9 \text{ J.m.C}^{-2}$
Rydberg constant R	$1.097 \times 10^7 \text{ m}^{-1}$	Ionization energy of the hydrogen atom E_0	13.6 eV

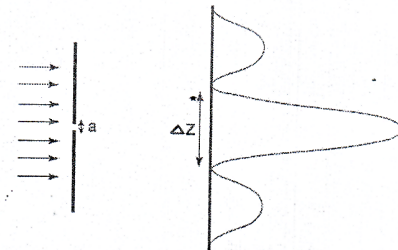
Question (5):

(12.5 Mark)

a- Choose the correct statement:

(2.5 Mark)

- 1- The figure shows the profile of intensity from a stream of electrons incident on a single slit. Δz is the width of the first fringe and a is the slit width. If the experiment is repeated with muons ($m_{\text{muon}} = 200 m_{\text{electron}}$) of the same velocity, what happens to the width of the central peak? Ignore the charge on these particles.



- (a) Δz remains unchanged. (b) Δz increases 200 times.
- (c) Δz decreases 200 times. (d) Δz increases $\sqrt{200}$ times.
- (e) Δz decreases $\sqrt{200}$ times.
- 2- For the hydrogen atom, which series describes electron transitions to the $n=1$ orbit "the lowest energy electron orbit"? Is it the:
- (a) Lyman series (b) Balmer series
- (c) Paschen series (d) Pfund series
- 3- The results of Rutherford's experiment, in which alpha particles were fired toward thin metal foils, were surprising because:
- (a) Some of the alpha particles were reflected almost straight backward.
- (b) Two alpha particles emerged from the foil for every alpha that entered.
- (c) Beta particles were created.
- (d) Some alpha particles were destroyed in collisions with the foil.
- 4- Muons are particles 200 times heavier than electrons. A muon and electron have identical kinetic energies. What can you say about their wavelengths λ ?
- (a) Both have the same wavelength λ , i.e., $\lambda_{\text{muon}} = \lambda_{\text{electron}}$.
- (b) $\lambda_{\text{muon}} > \lambda_{\text{electron}}$ (c) $\lambda_{\text{muon}} < \lambda_{\text{electron}}$
- (d) The muons do not have a de Broglie wavelength.
- 5- You are driving on a freeway at a relativistic speed. Straight ahead of you, a technician standing on the ground turns on a searchlight and a beam of light moves exactly directly at you as seen by the technician. As you observe the beam of light, do you measure the magnitude of the horizontal component of its velocity as:
- a- equal to c b- equal to zero c- greater than c d- less than c

b- Bohr's model failed to explain the difference between the spectrums of hydrogen isotopes, explain that, and discuss the modification to overcome this deficiency. (5 Mark)

c- If the total energy of an electron is three times its rest energy, what is the de Broglie wavelength? (5 Mark)

- c- Prove the Duane–Hunt law, which gives the minimum wavelength λ_{min} of X-rays that can be emitted by Bremsstrahlung in an X-ray tube by accelerating electrons through an excitation voltage V into a metal target. (5 Mark)

Question (4):

(12.5 Mark)

a- Put (✓) or (✗):

(2.5 Mark)

- 1- The Rutherford model failed to explain the hydrogen atom's spectrum. ()
- 2- Two events occur at different time are simultaneous. ()
- 3- The proper time is always the shortest time interval. ()
- 4- The conservation law of momentum is invariant under Lorentz transformation. ()
- 5- Maxwell's equations are invariant under Galilean transformation. ()

Question (3):

(12.5 Mark)

a- Put (✓) or (✗):

(2.5 Mark)

- 1- The pair production process, cannot occur in the vacuum. ()
 - 2- According to Max Plank, oscillator can emit radiation by dropped to any lowest energy state where the amount of energy emitted is $\Delta\varepsilon = nhf$. ()
 - 3- In Compton scattering, scattered photon has smaller wavelength than the incident one. ()
 - 4- No time lag between the illumination of the metal and the emission of the photoelectrons. ()
 - 5- Energy can be converted to mass but mass can't be converted to energy. ()
- b- In Compton Effect, an incident X-ray with a wavelength $\lambda = 5 \times 10^{-11} \text{ m}$ is incident on a calcite target. Find the wavelength of the X-ray scattered at a 30° angle. What are the largest shift and the smallest shift that can be expected in this experiment? (5 Mark)

b- In Bohr hydrogen atom, if the electron's angular momentum is equal to 3.15×10^{-34} J.sec, calculate its orbital quantum number and then calculate its energy? (5 Mark)

c- Derive the relation between the total energy E and the relativistic momentum p of a particle. (5 Mark)

Question (2):

(12.5 Mark)

a- Choose the correct statement:

(2.5 Mark)

- 1- Frank Hertz experiment has proved that:
 - a- The nucleus is the center of the atom's mass and charge and its size is very small.
 - b- The existence of energy levels experimentally.
 - c- The charge is quantized.
 - d- The electron has spin.
- 2- Rutherford experiment has proved that:
 - a- The nucleus is the center of the atom's mass and charge and its size is very small.
 - b- The existence of energy levels experimentally.
 - c- The charge is quantized.
 - d- The electron has spin.
- 3- A γ ray photon has five times the energy of an X-ray photon. What can be said about their wavelengths?
 - (a) We cannot say anything because we have no clue about their relative frequencies.
 - (b) $\lambda_{\gamma ray} = 5\lambda_{X-ray}$.
 - (c) $\lambda_{\gamma ray} = \lambda_{X-ray}/5$.
 - (d) $\lambda_{\gamma ray} = \lambda_{X-ray}$.
 - (e) $\lambda_{\gamma ray} = (\lambda_{X-ray})^2$.
- 4- Consider a hydrogen atom and a singly ionized helium atom. Which atom has the lower ground state energy?
 - (a) Hydrogen
 - (b) Helium
 - (c) The ground state energy is the same for both.
- 5- The collision between a photon and a free electron was first explained by which of the following scientists?
 - (a) Einstein
 - (b) Heisenberg
 - (c) Compton
 - (d) Bohr

- c- Write Bohr's hypotheses for his atomic model. Using these assumptions, prove that the fine-structure constant α is very nearly equal to $1/137$. The quantity α , which is equal to the ratio v_1/c where v_1 is the velocity of the electron in the first circular Bohr orbit of Hydrogen atom and c is the speed of light in vacuum. (5 Mark)



Answer four (4) only of the following questions:

Question (1):

(12.5 Mark)

a- Put (✓) or (✗):

(2.5 Mark)

- 1- X-ray is the reverse phenomenon of photoelectric emission. ()
- 2- Compton shift $\Delta\lambda$ depends on the type of scattering material. ()
- 3- The probability of pair production increases only by decreasing the photon energy. ()
- 4- In blackbody radiation, as the temperature increases, the maximum of the curve shifts toward higher frequencies. ()
- 5- In photoelectric effect, the maximum kinetic energy of photoelectrons depends on the intensity of incident electromagnetic waves. ()

b- At what speed does a clock move if it runs at a rate which is one-half the rate of a clock at rest?

(5 Mark)

b- Put (✓) or (X):

(5 Mark)

- 1- The probability of pair production increases only by decreasing the photon energy. ()
- 2- In blackbody radiation, as the temperature increases, the maximum of the curve shifts toward higher frequencies. ()
- 3- In photoelectric effect, the maximum kinetic energy of photoelectrons depends on the intensity of incident electromagnetic waves. ()
- 4- The pair production process, cannot occur in the vacuum. ()
- 5- According to Max Plank, oscillator can emit radiation by dropped to any lowest energy state where the amount of energy emitted is $\Delta E = nhf$. ()
- 6- No time lag between the illumination of the metal and the emission of the photoelectrons. ()
- 7- Energy can be converted to mass but mass can't be converted to energy. ()
- 8- The Rutherford model failed to explain the hydrogen atom's spectrum. ()
- 9- Two events occur at different time are simultaneous. ()
- 10- Maxwell's equations are invariant under Galilean transformation. ()

c- What is the momentum of a photon with 1 eV energy? Give the corresponding wavelength in Angstroms.

(5 Mark)

Question (4):

a- Write the postulates of the special theory of relativity.

(12.5 Mark)

(2.5 Mark)

b- The x-ray spectrum is composed of two components, one continuous and the other characteristic the anode of Röntgen tube, explain that. Illustrate the composition and how the Röntgen tube work.

(5 Mark)

- c- Although the classical Physics failed to explain the scattering of x-rays from free electrons, Compton succeeded to explain that by using the modern physics. Discuss that. (5 Mark)

Question (5):

(12.5 Mark)

- a- Estimate the surface temperature of the Sun from the following information. The wavelength marking the maximum power emission of the Sun " λ_{max} " is 500 nm. (2.5 Mark)

c- Although the classical Physics failed to explain the scattering of x-rays from free electrons, Compton succeeded to explain that by using the modern physics. Discuss that. (5 Mark)

Question (5):

(12.5 Mark)

a- Estimate the surface temperature of the Sun from the following information. The wavelength marking the maximum power emission of the Sun " λ_{max} " is 500 nm. (2.5 Mark)

b- Prove that the rest mass of any particle moving with speed of light c "such as photon or neutrino" is zero. (5 Mark)



The exam is written in nine pages

Answer four (4) only of the following questions:

Question (1):

a- Express m the relativistic mass of a photon in terms of h , λ and c .

b- Write Bohr's hypotheses for his atomic model. Using these assumptions, prove that the electron's velocity decreases by increasing the quantum number n . (5 Mark)

- c- Can an electron in a hydrogen atom have a speed of 3.641×10^6 m/s? If so, what are its energy and the radius of its orbit? (5 Mark)

Question (2):

(12.5 Mark)

- a- X-ray radiation is the reverse phenomenon of photoelectric emission, explain that. (2.5 Mark)

2- Derive the time dilation relation.

(5 Mark)

- c- The work function for the photoeffect in potassium is 2.25 eV. For the case when light with a wavelength of 3.6×10^{-7} m falls on the potassium, calculate:
- 1- The braking potential V_0 of the photoelectrons.
 - 2- The kinetic energy of the fastest of the emitted electrons.
 - 3- The velocity of the fastest of the emitted electrons.

(5 Mark)

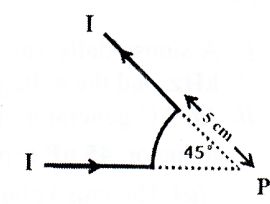
Question (3):

(12.5 Mark)

- a- A photon releases a photoelectron with an energy of 2 eV from a metal which has a work function of 2 eV. What is the smallest possible value for the energy of this photon? (2.5 Mark)



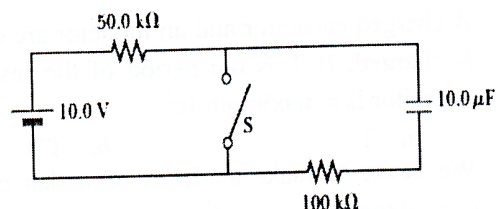
Part I: In the following multiple choice questions, please choose the correct answer. You must write down the steps to get the correct answer (20 Grade/2 points each)

- A charged capacitor and an inductor are connected in series. At time $t = 0$ the current is **zero**, but the capacitor is charged. If T is the period of the resulting oscillations, the next time after $t = 0$ that the **charge** on the capacitor is a maximum is:
 - T
 - $T/4$
 - $T/2$
 - $2T$
- We desire to make an **LC** circuit that oscillates at **100 Hz** using an inductance of **2.5 H**. We also need a capacitance of:
 - 1 F
 - 1 mF
 - 1 μ F
 - 1 pF
- A capacitor in an **LC** oscillator has a maximum potential difference of **15 V** and a maximum energy of **360 μ J**. At a certain instant the energy in the capacitor is **40 μ J**. At that instant what is the **emf** induced in the inductor?
 - zero
 - 5 V
 - 10 V
 - 15 V
- An **RLC** series circuit has $L=100$ mH and $C=1$ μ F. They are connected to **10³ Hz** source and the source **emf** is found to lead the current by **75°**. Then, the value of **R** is:
 - 10 Ω
 - 75 Ω
 - 95 Ω
 - 126 Ω
- A **35 μ F** capacitor is connected to a source of sinusoidal **emf** with a frequency of **400 Hz** and a maximum **emf** of **20 V**. The maximum current is:
 - 0.28 A
 - 1.8 A
 - 230 A
 - 1400 A
- The magnetic dipole moment of an atomic electron is typically:
 - Much less than a Bohr magneton.*
 - A few Bohr magnetons.*
 - Much greater than a Bohr magneton.*
 - Not related to the value of the Bohr magneton.*
- A magnetic field $\vec{B}_0$ is applied to a paramagnetic substance. In the interior the magnetic field produced by the magnetic dipoles of the substance is:
 - Less than $\vec{B}_0$ and in the opposite direction.*
 - Greater than $\vec{B}_0$ and in the same direction.*
 - Less than $\vec{B}_0$ and in the same direction.*
 - The same as $\vec{B}_0$.*
- The segment of wire is formed into the shape shown in the figure below and carries a current $I=3$ A. The resulting magnetic field at the point **P** is:
 
 - 1.5 μ T
 - 4.7 μ T
 - 9.43 μ T
 - 12 μ T
- A **10** turn ideal solenoid has an inductance of **4 mH**. To generate an **emf** of **2 V** the current should change at a rate of:
 - 5 A/s
 - 50 A/s
 - 250 A/s
 - 500 A/s
- The behavior of ferromagnetic domains in an applied magnetic field gives rise to:
 - Hysteresis.*
 - Ferromagnetism.*
 - The Curie law.*
 - Gauss' law for magnetism.*

Part II: Answer only FOUR questions from the following five questions (30 Grade/ 7.5 points each)

Question 1:

- i. An uncharged capacitor (C) and a resistor (R) are connected in series to a battery ($\mathcal{E}$), where $\mathcal{E} = 12 \text{ V}$, $C = 5 \mu\text{F}$, and $R = 8 \times 10^5 \Omega$. Find the time constant of the circuit, the maximum charge on the capacitor, the maximum current in the circuit, and the charge and current as functions of time.
- ii. In the shown circuit, the switch S has been open for a long time. It is then suddenly closed. Determine the time constant (a) before the switch is closed and (b) after the switch is closed. (c) Let the switch be closed at $t=0$. Determine the current in the switch as a function of time.

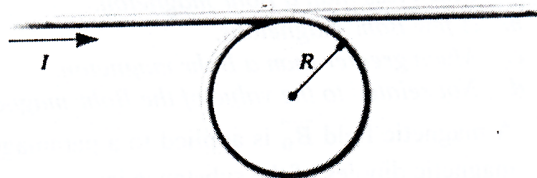


Question 2:

- i. (a) Calculate the inductance of an air-core solenoid containing **300 turns** if the length of the solenoid is **25 cm** and its cross-sectional area is **4 cm²**; (b) calculate the self-induced *emf* in the solenoid if the current it carries is decreasing at the rate **50 A/s**.
- ii. Consider an LC circuit in which $L = 500 \text{ mH}$ and $C = 0.1 \mu\text{F}$. (a) What is the resonance frequency ω_0 ? (b) If a resistance of **1 kΩ** is introduced into this circuit, what is the frequency of the damped oscillations? (c) By what percentage does the frequency of the damped oscillations differ from the resonance frequency?

Question 3:

- i. Two coils are close to each other. The first coil carries a current given by $i(t) = 8e^{-2.8t}$, where i is in amperes and t is in seconds. At $t = 0.75 \text{ s}$, the *emf* measured across the second coil is **-6.5 V**. What is the mutual inductance of the coils?
- ii. A conductor consists of a circular loop of radius $R = 20 \text{ cm}$ and two straight sections (length of each one $= 2.5 R$) as shown in Figure. The wire lies in the plane of the paper and carries a current $I = 6 \text{ A}$. Find the magnetic field (magnitude and direction) at the center of the loop.



Question 4:

- i. A sinusoidally varying voltage is applied across an **8 mF** capacitor. The frequency of the applied voltage is **3 kHz**, and the voltage amplitude is **30 V**. Find the displacement current in the capacitor.
- ii. An AC generator supplies a peak (not rms) voltage of **150 V** at **60 Hz**. It is connected in series with a **35 mH** inductor, **45 μF** capacitor and **85 Ω** resistor. Determine the following:
 - (a) The rms voltage of the generator
 - (b) The impedance of the circuit
 - (c) The power factor for this circuit
 - (d) The resonant frequency of this circuit

Question 5:

- i. The planetary model of the hydrogen atom consists of an electron in a circular orbit about a proton. The motion of the electron of charge $1.6 \times 10^{-19} \text{ C}$ creates an electric current. The radius of the electron orbit is $5.3 \times 10^{-11} \text{ m}$ and the electron's velocity is $2.2 \times 10^6 \text{ m/s}$. What is the magnetic field strength at the location of the proton?
- ii. Coil 1 has $L_1 = 25 \text{ mH}$ and $N_1 = 100$ turns. Coil 2 has $L_2 = 40 \text{ mH}$ and $N_2 = 200$ turns. The coils are fixed in place; their mutual inductance M is **3 mH**. A **6 mA** current in coil 1 is changing at the rate of **4 A/s**.
 - (a) What is the magnetic flux Φ_{12} links coil 1?
 - (b) What is the self-induced *emf* appears in coil 1?
 - (c) What is the magnetic flux Φ_{21} links coil 2?
 - (d) What is the mutually induced *emf* appears in coil 2?

Answer the following questions

I-a)-i- Prove that the gas molecules pressure on the wall of gas container, depends on the average kinetic energy of these molecules. Show that this energy is equally distributed along three coordinates (X, Y, Z)

ii- Prove that the number of gas molecules per unit volume decreases with increasing the altitude measured from the ground surface. Show that the pressure of these molecules at infinite altitude measured from the ground center is not equal zero.

b-i- Give an expression for the molecular distribution function according to the molecules velocity components at any altitude. Show the shape of this function and explain on this shape the properties of this function. Deduce an expression for the total number of gas molecules per unit volume according to their velocity components along three Cartesian axes

ii- Prove that the molecules velocity distribution function depends on the molecules average kinetic energy and the gas absolute temperature. Explain on a diagram the effect of this temperature on this function

C- Calculate the following: i- the average kinetic energy gas molecules at the absolute zero temperature (in electron –volt units). ii- the root mean square velocity $\bar{C}$, the average velocity $\bar{C}$ and the most probable velocity C_m of the gas molecules where the gas density $\rho = 1.42 \text{ Kg m}^{-3}$, the number of molecules per unit volume $n = 2.7 \times 10^{25} \text{ m}^{-3}$ and the gas temperature $T = 127^\circ \text{C}$ (using Boltzmann's constant $k = 1.38 \times 10^{-23} \text{ J/K}$)

2-a- Prove that the slope of the relation curve between the ideal gas pressure and its volume during the adiabatic variation is greater than that slope during the isothermal variation of this gas. (show schematic diagram of this relation in the two cases). Prove that $C_p/C_v = \gamma$ for the ideal gas.

b- Prove that the work done during the isothermal variation of the ideal gas is greater than that during the adiabatic variation of this gas. Deduce the relation govern the adiabatic variation of an ideal gas.

c) i- Assume that 10^{-2} m^3 of air is compressed to $2 \times 10^{-3} \text{ m}^3$, show which is the best and cheaper: the gas is compressed isothermally or adiabatically. (where $\gamma = 1.4$)

ii- Calculate the work done when one gram of oxygen gas is compressed adiabatically at the atmospheric pressure and zero absolute temperature till a final volume V_f equals to half of its initial volume V_i (where $R = 8.31 \text{ J/mol.K}$ and R_{O_2} for one gram of oxygen gas equals $R/32$ and $\gamma = 1.4$)

3-a- Prove that the gas molecule's mean free path is inversely proportional to the number of molecules per unit volume. Deduce the relation between the gas viscosity and the gas molecule mean free path.

b- i- Derive an equation for the curve passes all the maximum and minimum points on the isothermal Van-der Vaal's curves. Define on these curves the position and coordinates of the top of this curve. Using a diagram prove that Van-der Vaal's equations of the real gas can describe this gas in its gaseous, liquid states and during the change between these two states

ii- Write an expression for the following : the critical volume, the critical pressure , the critical temperature. Deduce the temperature at which the real gas behaves as an ideal gas.

c- A gas molecule of diameter 3×10^{-10} m at 27°C and one atmospheric pressure calculate the mean free path of this molecule and the average number of collisions per second occurred between two molecules where the root mean square velocity in this case equals 582.6 m/s. Assuming that the molecule mass is 46.23×10^{-27} Kg, calculate the gas viscosity using $k = 1.38 \times 10^{-23} \text{ J/K}^\circ$.

4-a-i- Explain on a schematic diagram how can the heat engine complete the Carot cycle.

ii- Derive an expression for : the total work done during this cycle and the efficiency of this heat engine.

b-i- Deduce an expression for the change of internal energy due to the change of both entropy and volume of the system. Write a formula of the following:

- Maxwell's equations in thermodynamics
- First, second and third (Tds) equations, (give the physical meaning for each symbol used in these equations)

ii- Derive an expression for $(C_P - C_V)$ in terms of isothermal elastic and thermal expansion coefficients. Using this expression to prove that $(C_P - C_V) = R$

c-i- Deduce the equation of total entropy change of an ideal gas of mass M and molecular weight μ when the gas is expanded isothermally from an initial volume V_i to a final volume V_f .

ii- Calculate the entropy change during the gas isothermal expansion from an initial volume V_i to a final volume $V_f = 4 V_i$ where $R = 8.314 \text{ J/mol K}^\circ$.

With my best wishes
Prof. Dr. Abdel-Haleem Turkey

Physical Chemistry Examination (C-230) for Second Level Students

Answer the following questions:

1) Answer Only Three from the following: (16.5 Marks)

- Derive Kinetic equation for determination the specific rate constant and the half life time for the following reaction: $3A \xrightarrow{K_2} \text{products}$
- Discuss the effect of temperature on the reaction velocity.
- Discuss the theory of absolute reaction rates.
- The decomposition of acetone dicarboxylic acid has the rate constant , $K=2.46 \times 10^{-5}$ at 273 °K and 1.63×10^{-5} at 303 °K. Find the value of ΔE^* . ($R=1.978$).

2) Answer Only Seven from the following: (33.5 Marks)

- Discuss the temperature dependence of entropy.
- Determine the heat needed to raise 100 gm of Pb from 0 to 500 °C, given its specific heats to be 0.031 (solid) and 0.038 (liquid). Its heat of fusion is 5.9 cal/g , its melting point is 330°C.
- The density of ice at 0°C is 0.9 g cm^{-3} and has an entropy of $38 \text{ cal mol}^{-1} \text{ deg}^{-1}$. The density of liquid water at this temperature is 1 g cm^{-3} and has an entropy of $60 \text{ cal mol}^{-1} \text{ deg}^{-1}$. Given these data , calculate $\Delta S, \Delta H$ and ΔE for the conversion of 36 gm of ice to liquid water at the normal melting point. (M.wt. of $\text{H}_2\text{O}=18 \text{ g mole}^{-1}$)
- Calculate the enthalpy change when 540 g of water freezes at constant pressure and a temperature of -30°C. At 0°C , ΔE is $-1435 \text{ cal mole}^{-1}$, and C_p is 18 and $8.8 \text{ cal mol}^{-1} \text{ deg}^{-1}$ for water and ice , respectively.
- Given , for acetic acid that $\Delta E_{\text{fus}}=2600 \text{ cal mol}^{-1}$ at its melting point 17°C and $\Delta H_{\text{vap}}=6000 \text{ cal mol}^{-1}$ at its boiling point 120°C. Calculate the change in entropy that takes place when 120 gm of solid acetic acid is melted at its melting point and vaporized at its boiling point , all under constant pressure taken as 1 atm. Assume that molar heat capacity of acetic acid is $27.6 \text{ cal deg}^{-1} \text{ mol}^{-1}$. (M.wt of acetic acid=60g/mole)
- Derive an expression for the efficiency of Carnot's engine working between two temperature T_1 and T_2 .
- At 760 mm/Hg , 100gm of benzene is vaporized at its boiling point of 80°C. Calculate : a) W_{rev} , b) q , c) ΔH , d) ΔE
The heat of vaporization is 7.6 K cal/mol , M.wt of benzene =78gm/mol.
- Find the cell potential for cell whose reaction equations of the two halves are:
 $\text{Ni}^{2+} + 2e \longrightarrow \text{Ni} \quad E^\circ = -0.25$
 $\text{Sn} \longrightarrow \text{Sn}^{2+} + 2e \quad E^\circ = +0.14$
and the concentrations are $\text{Ni}^{2+} = 1.3 \times 10^{-1}$ and $\text{Sn}^{2+} = 1.0 \times 10^{-5} \text{ mol/L}$.
Is the reaction spontaneous as written?



Final Exam of Modern Physics - Course Code: P215 - (50 Marks)

Answer ONLY FIVE from the Following Questions:

Q1: (A) Verify that the law of conservation of linear momentum is invariant under Galilean transformation. [4 Marks]

(B) In the inertial system S , an event is observed to take place at point A on the x -axis and 10^{-6} sec later another event takes place at point B, 900 m further down. Find the magnitude and direction of the velocity of S' with respect to S in which these two events appear simultaneous. [3 Marks]

(C) Event 1 occurs at $x_1 = 20$ m, $t_1 = 2 \times 10^{-8}$ s and event 2 occurs at $x_2 = 60$ m, $t_2 = 3 \times 10^{-8}$ s in frame S . A frame S' moves relative to S with velocity $v = 0.6c$ m/s along the $X-X'$.

(i) What is the separation of two events in frame S and S' ?

(ii) What is the time interval between two events in frame S and S' ? [3 Marks]

Q2: (A) Show that Maxwell's equations for the propagation of electromagnetic waves are Lorentz invariant. [4 Marks]

(B) Time interval between two events measured by moving clock is longer than time interval measured by clock at rest by the relativistic factor γ . Prove that? [4 Marks]

(C) Determine the speed of the Lorentz transformation in the x -direction for which the velocity in the frame S of a particle is $u = (c/\sqrt{2}, c/\sqrt{2})$ and the velocity in frame S' is seen as $u' = (-c/\sqrt{2}, c/\sqrt{2})$. [2 Marks]

Q3: (A) Show that for slow speeds, the Doppler shift can be approximated as $\Delta\lambda/\lambda \approx v/c$ where $\Delta\lambda$ is the change in wavelength. In spectroscopic measurements of light at $\lambda = 397$ nm coming from a galaxy in Ursa Major reveal a red shift of 20.0 nm. What is the speed of the galaxy? [4 Marks]

(B) If the total energy of a particle is n times its rest energy, what is its momentum? [3 Marks]

(C) A spaceship in the form of a triangle flies by an observer at $0.950c$. When the ship is measured by an observer at rest with respect to the ship the distances x and y are found to be 50.0 m and 25.0 m, respectively. What is the shape of the ship as seen by an observer who sees the ship in motion along the x -direction? [3 Marks]

Q4: (A) Derive the frequency f and wavelength λ of emitted spectral line of Hydrogen atom according to Bohr Model. ($E_n = -\frac{me^4}{8h^2\epsilon_0^2} \times \frac{1}{n^2}$). [4 Marks]

(B) Write the names and equations of first three spectral series in Hydrogen atom and its conditions. [3 Marks]

(C) Photon emitted from transition of electron from $n_i = 5$, the wavelength of emitted photon is 12.9×10^{-7} m. Calculate n_f and frequency of emitted photon. What is the series of this photon? [3 Marks]

-
- Q5: (A) What is the main three concepts of the Rutherford's atomic model? [3 Marks]
- (B) Discuss how de Broglie Explained Bohr's Quantization Condition. [4 Marks]
- (C) Assume an electron in the second orbit of Hydrogen atom, (i) Calculate the orbit's radius
(ii) Calculate the wavelength of the wave associated to this electron. [3 Marks]
-

- Q6: (A) Verify Stefan's law from Plank's law, where: [4 Marks]

$$E(f, T) df = \frac{2\pi h f^3}{c^2} \left(\frac{1}{e^{hf/k_B T} - 1} \right) df \quad \& \quad \int_0^\infty \frac{x^3}{(e^x - 1)} dx = \frac{\pi^4}{15}$$

- (B) The wavelength of maximum intensity of the sun's radiation is observed to be near 500 nm. Assume the sun to be a blackbody and calculate: (i) the sun's surface temperature, (ii) the power per unit area (total emitted radiant energy) $R(T)$ emitted from the sun's surface, (iii) the power received by Earth per unit area each day from the sun's radiation. [3 Marks]
- (C) Light of wavelength 2000 Å falls on aluminium surface, which has work function of 4.2 eV. Calculate: (i) maximum kinetic energy of photoelectrons. (ii) minimum kinetic energy of photoelectrons. (iii) threshold wavelength. (iv) stopping potential. [3 Marks]
-

Constants: $h = 6.62607004 \times 10^{-34} \text{ m}^2 \text{ kg} / \text{s} = 4.1357 \times 10^{-15} \text{ eV s}$,

$$\sigma = 5.6705 \times 10^{-8} \text{ J s}^{-1} \text{ m}^{-2} \text{ K}^{-4},$$

$$R = 1.097373 \times 10^7 \text{ m}^{-1},$$

$$a_0 = 5.32 \times 10^{-11} \text{ m}.$$

End of the Exam

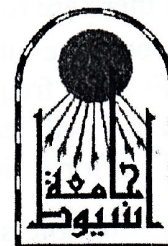
Good Luck

Dr. Haní Negm

2018/2019



Physics Department
Assiut University



Physics 271P – PHYSICAL OPTICS & OPTICAL FIBERS

THIS TEST HAS TEN PAGES

DURATION OF TEST: 3 HOURS

DATE: 30th DECEMBER 2018.

Answer ONLY 30 question from section A.

Answer ALL questions in section B.

A. Multiple Choice: Multiple Choice: Identify the choice that best completes the statement or answers the question. [30 marks]

1. Fully constructive interference between two sinusoidal waves of the same frequency occurs only if they:

- A. travel in opposite directions and are in phase
- B. travel in opposite directions and are 180° out of phase
- C. travel in the same direction and are in phase
- D. travel in the same direction and are 180° out of phase

2. Fully destructive interference between two sinusoidal waves of the same frequency and amplitude occurs only if they:

- A. travel in opposite directions and are in phase
- B. travel in opposite directions and are 180° out of phase
- C. travel in the same direction and are in phase
- D. travel in the same direction and are 180° out of phase

3. Standing waves are produced by the interference of two traveling sinusoidal waves, each of frequency 100 Hz. The distance from the second node to the fifth node is 60 cm. The wavelength of each of the two original waves is:

- A. 50 cm
- B. 40 cm
- C. 30 cm
- D. 20 cm

4. Huygens' construction can be used only:

- A. for light
- B. for an electromagnetic wave
- C. for transverse waves
- D. for all of the above

5. Consider (I) the law of reflection and (II) the law of refraction. Huygens' principle can be used to derive:

- A. only I
- B. only II
- C. both I and II
- D. neither I nor II

6. Units of "optical path length" are:

- A. m^{-1}
- B. m
- C. m/s
- D. Hz/m

7. Interference of light is evidence that:

- A. the speed of light is very large
- B. light is a transverse wave
- C. light is electromagnetic in character
- D. light is a wave phenomenon

8. The reason there are two slits, rather than one, in a Young's experiment is:
- to increase the intensity
 - one slit is for frequency, the other for wavelength
 - to create a path length difference
 - one slit is for $\vec{E}$ fields, the other is for $\vec{B}$ fields
9. In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in phase by a multiple of:
- $\pi/4$
 - $\pi/2$
 - π
 - 2π
10. Waves from two slits are in phase at the slits and travel to a distant screen to produce the third side maximum of the interference pattern. The difference in the distance traveled by the waves is:
- half a wavelength
 - a wavelength
 - three halves of a wavelength
 - three wavelengths
11. A monochromatic light source illuminates a double slit and the resulting interference pattern is observed on a distant screen. Let d = center-to-center slit spacing, a = individual slit width, D = screen-to-slit distance, and l = adjacent dark line spacing in the interference pattern. The wavelength of the light is then:
- d/D
 - Ld/a
 - da/D
 - D/a
12. Light from a small region of an ordinary incandescent bulb is passed through a yellow filter and then serves as the source for a Young's double-slit experiment. Which of the following changes would cause the interference pattern to be more closely spaced?
- Use slits that are closer together
 - Use a light source of lower intensity
 - Use a light source of higher intensity
 - Use a blue filter instead of a yellow filter
13. In a Young's double-slit experiment, light of wavelength 500nm illuminates two slits that are separated by 1 mm. The separation between adjacent bright fringes on a screen 5m from the slits is:
- 0.10 cm
 - 0.25 cm
 - 0.50 cm
 - 1.0 cm
14. In a Young's double-slit experiment, the separation between slits is d and the screen is a distance D from the slits. $D \gg d$ and λ is the wavelength of the light. The number of bright fringes per unit width on the screen is:
- $d/D\lambda$
 - $D\lambda/d$
 - $D/d\lambda$
 - λ/Dd
15. In a Young's experiment, it is essential that the two beams:
- have exactly equal intensity
 - be exactly parallel
 - travel equal distances
 - come originally from the same source
16. In a Young's double-slit experiment, a thin sheet of mica is placed over one of the two slits. As a result, the center of the fringe pattern (on the screen) shifts by an amount corresponding to 30 dark bands. The wavelength of the light in this experiment is 480nm and the index of the mica is 1.60. The mica thickness is:
- 0.090mm
 - 0.012mm
 - 0.014mm
 - 0.024mm

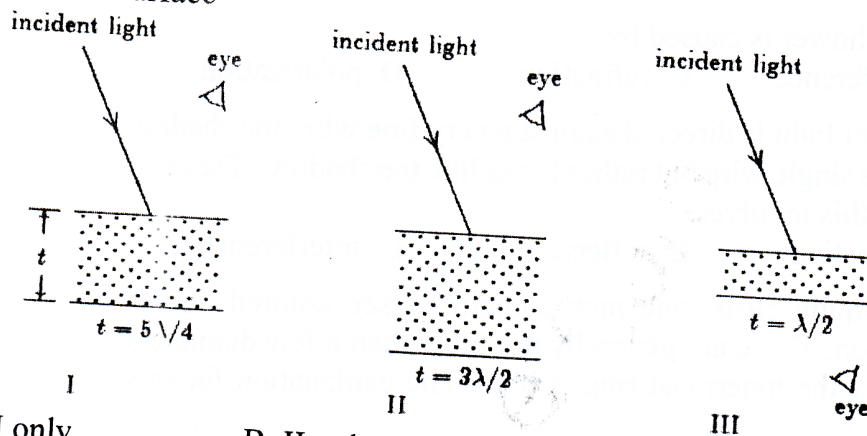
17. Monochromatic light, at normal incidence, strikes a thin film in air. If λ denotes the wavelength in the film, what is the thinnest film t in which the reflected light will be a maximum?

- A. $t \ll \lambda$ B. $t = \lambda/4$ C. $t = \lambda/2$ D. $t = 3\lambda/4$

18. A soap film is illuminated by white light normal to its surface. The index of refraction of the film is 1.50. Wavelengths of 480nm and 800nm and no wavelengths between are be intensified in the reflected beam. The thickness of the film is:

- A. 1.5×10^{-5} cm B. 2.4×10^{-5} cm C. 3.6×10^{-5} cm D. 4.0×10^{-5} cm

19. Three experiments involving a thin film (in air) are shown. If t denotes the film thickness and λ denotes the wavelength of the light in the film, which experiments will produce constructive interference as seen by the observer? The incident light is nearly normal to the surface



- A. I only B. II only C. III only D. I and III only

20. In a thin film experiment, a wedge of air is used between two glass plates. If the wavelength of the incident light in air is 480 nm, how much thicker is the air wedge at the 16th dark fringe than it is at the 6th?

- A. 2400nm B. 4800nm C. 240nm D. 480nm

21. If two light waves are coherent:

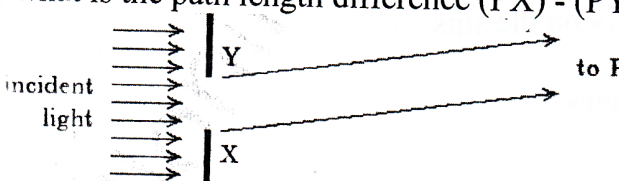
- A. are of the same frequency.
B. are of the same amplitude, frequency, and maintain a constant phase difference.
C. are of the same amplitude, and maintain a constant phase difference.
D. are of the same frequency and amplitude.

22. To obtain an observable double-slit interference pattern:

- A. the light must be incident normally on the slits
B. the light must be monochromatic
C. the light must consist of plane waves
D. the light must be coherent

23. Sound differs from light in that sound:

- A. is not subject to diffraction
B. is a torsional wave rather than a longitudinal wave
C. is a longitudinal wave rather than a transverse wave
D. is always monochromatic

24. Radio waves are readily diffracted around buildings whereas light waves are negligibly diffracted around buildings. This is because radio waves:
- are plane polarized
 - have much longer wavelengths than light waves
 - have much shorter wavelengths than light waves
 - are nearly monochromatic (single frequency)
25. Diffraction plays an important role in which of the following phenomena?
- The sun appears as a disk rather than a point to the naked eye
 - Light is bent as it passes through a glass prism
 - A cheerleader yells through a megaphone
 - A farsighted person uses eyeglasses of positive focal length
26. The rainbow seen after a rain shower is caused by:
- diffraction
 - interference
 - refraction
 - polarization
27. When a highly coherent beam of light is directed against a very fine wire, the shadow formed behind it is not just that of a single wire but rather looks like the shadow of several parallel wires. The explanation of this involves:
- refraction
 - diffraction
 - reflection
 - interference
28. When the atmosphere is not quite clear, one may sometimes see colored circles concentric with the Sun or the Moon. These are generally not more than a few diameters of the Sun or Moon and invariably the innermost ring is blue. The explanation for this phenomena involves:
- reflection
 - refraction
 - interference
 - diffraction
29. In the equation: $\sin \theta = \lambda/a$ for single-slit diffraction, θ is:
- the angle to the first minimum
 - the angle to the second maximum
 - the phase angle
 - the slit width
30. In the equation: $\phi = (2\pi a/\lambda) \sin \theta$ for single-slit diffraction, ϕ is:
- the angle to the first minimum
 - the angle to the second maximum
 - the phase angle between the extreme rays
 - $N\pi$ where N is an integer
31. The diagram shows a single slit with the direction to a point P on a distant screen shown. At P, the pattern has its maximum nearest the central maximum. If X and Y are the edges of the slit what is the path length difference (PX) - (PY)?
- 
- $\lambda/2$
 - λ
 - $3\lambda/2$
 - 2λ
32. When 450-nm light is incident normally on a certain double-slit system the number of interference maxima within the central diffraction maximum is 5. When 900-nm light is incident on the same slit system the number is:
- 2
 - 3
 - 5
 - 9

33. In a double-slit diffraction experiment the number of interference fringes within the central diffraction maximum can be increased by:
- A. decreasing the slit width
 - B. decreasing the wavelength
 - C. decreasing the slit separation
 - D. increasing the slit width
34. In the equation: $d \sin \theta = m\lambda$ for the lines of a diffraction grating m is:
- A. the number of slits
 - B. the slit width
 - C. the slit separation
 - D. the order of the line
35. In the equation: $d \sin \theta = m\lambda$ for the lines of a diffraction grating d is:
- A. the number of slits
 - B. the slit width
 - C. the slit separation
 - D. the order of the line
36. An N-slit system has slit separation d and slit width a . Plane waves with intensity I and wavelength λ are incident normally on it. The angular separation of the lines depends only on:
- A. a and N
 - B. a and λ
 - C. N and λ
 - D. d and λ
37. Polarization is a property applying to transverse waves? and it refers to
- A. prevention of electricity flowing in an electrolyte solution
 - B. rapid dissolving of magnesium in dilute acid
 - C. slow dissolving of magnesium in concentrated acid
 - D. electricity flowing in an electrolyte solution
38. A 600-nm wave light is incident on a diffraction grating with a ruling separation of 1.7×10^{-6} m. The second order line occurs at a diffraction angle of:
- A. 0
 - B. 10°
 - C. 21°
 - D. 45°
39. Monochromatic light is normally incident on a diffraction grating that is 1 cm wide and has 10,000 slits. The first order line is deviated at a 30° angle. What is the wavelength, in nm, of the incident light?
- A. 300
 - B. 400
 - C. 500
 - D. 600
40. A light spectrum is formed on a screen using a diffraction grating. The entire apparatus (source, grating and screen) is now immersed in a liquid of refractive index 1.33. As a result, the pattern on the screen:
- A. remains the same
 - B. spreads out
 - C. crowds together
 - D. disappears
41. The best definition of polarization is
- A. Orientation of dipoles in random direction
 - B. Electric dipole moment per unit volume
 - C. Orientation of dipole moments
 - D. Change in polarity of every dipole
42. The spacing between adjacent slits on a diffraction grating is 3λ . The deviation θ of the first order diffracted beam is given by:
- A. $\sin(\theta/2) = 1/3$
 - B. $\sin(\theta/3) = 2/3$
 - C. $\sin(\theta) = 1/3$
 - D. $\tan(\theta/2) = 1/3$

Problems: Answer the following questions.

[20 marks]

1. A laser beam is incident on two slits with a separation of 0.200 mm, and a screen is placed 5.00 m from the slits. An interference pattern appears on the screen. If the angle from the center fringe to the first bright fringe to the side is 0.181° , what is the wavelength of the laser light?

SOLUTION:

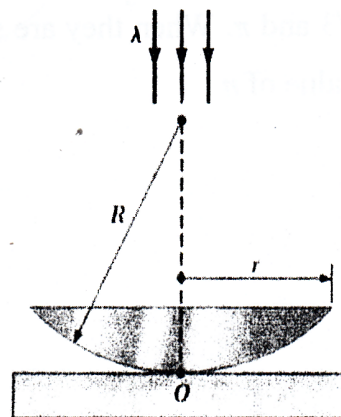
2. Light of wavelength 530 nm illuminates a pair of slits separated by 0.300 mm. If a screen is placed 2.00 m from the slits, determine the distance between the first and second dark fringes.

SOLUTION:

3. Light of wavelength 620 nm falls on a double slit, and the first bright fringe of the interference pattern is seen at an angle of 15.0° with the horizontal. Find the separation between the slits.

SOLUTION:

4. In a Newton's-rings experiment, a plano-convex glass ($n = 1.52$) lens having radius $r = 5.00$ cm is placed on a flat plate as shown in Figure P37.59. When light of wavelength $\lambda = 650$ nm is incident normally, 55 bright rings are observed, with the last one precisely on the edge of the lens. (a) What is the radius R of curvature of the convex surface of the lens? (b) What is the focal length of the lens?



SOLUTION:

5. Four harmonic waves of equal frequencies and equal intensities I_0 have phase angles $0, \pi/3, 2\pi/3$ and π . When they are superposed, the intensity of the resulting wave is nI_0 .

Find the value of n .

SOLUTION:

END OF EXAM



Physics Department
Assiut University



Physics 212P – Oscillations and Waves

THIS TEST HAS TEN PARTS

DURATION OF TEST: 3 HOURS

Date: 05th January 2019.

Examiner: Dr. Ahmed Mostafa Army

Answer ONLY 30 question from section A.

Answer ALL questions in section B.

A. Multiple Choice: Multiple Choice: Identify the choice that best completes the statement or answers the question. [30 marks]

1. Time taken to complete a wave is termed as:

- a. span
- b. period
- c. life
- d. duration

2. Any two shortest points in a wave that are in phase are termed as.

- a. wave distance
- b. wavelength
- c. phase length
- d. amplitude

3. Direction of waves is parallel to distance of vibration in

- a. transverse waves
- b. longitudinal waves
- c. transverse and longitudinal
- d. none of the waves

4. Motion that is repeated at regular intervals is termed as

- a. vibration
- b. oscillation
- c. ventilation
- d. periodic motion

5. Energy in waves is transfer and medium is

- a. also transferred
- b. not transferred
- c. medium does not exist
- d. may or may not transfer

6. Two points on same line at same distance and speed are said to be in
- parallel
 - phase
 - displacement
 - pair
7. A wave is made up of
- air molecules
 - vibrations
 - periodic motions
 - oscillations
8. If wavelength of a wave is denoted as ' λ ' and amplitude is denoted as 'A', then shortest horizontal distance between any crest and trough is equal to
- $1/2$ of λ
 - λ
 - $1/2$ of A
 - A
9. In which type of vibrations, amplitude of vibration goes on decreasing every cycle?
- Damped vibrations
 - Undamped vibrations
 - Both a. and b
 - None of the above
10. Which among the following is the fundamental equation of S.H.M.?
- $x + (k/m)x = 0$
 - $\ddot{x} + \omega^2 x = 0$
 - $x + (k/m)^2 x = 0$
 - $x^2 + \omega x = 0$
11. A wave is described by: $y(x, t) = 0.1 \sin(3x - 10t)$, where x is in meters, y is in centimeters, and t is in seconds. The angular frequency is:
- 0.10 rad/s
 - 3.0π rad/s
 - 10π rad/s
 - 10 rad/s
12. The displacement of a string carrying a traveling sinusoidal wave is given by: $y(x, t) = y_m \sin(kx - \omega t - \phi)$. At time $t = 0$ the point at $x = 0$ has a displacement of 0 and is moving in the positive y direction. The phase constant ϕ is:
- 45°
 - 90°
 - 135°
 - 180°
13. What is the maximum value of the acceleration a when: $x = A \cos(\omega t + \phi)$?
- ω
 - ωt
 - $\omega^2 A$
 - $A\phi$

14. When standing waves are present on a string of length L the frequency of the third harmonic is
- a. $f/2L$
 - b. f/L
 - c. $3f/2L$
 - d. $2f/L$
15. A simple pendulum on the Earth has a period of one second. What would be its period in s on the moon where the acceleration due to gravity is $1/6$ that of Earth?
- a. 6.00 s
 - b. 2.45 s
 - c. 1.00 s
 - d. 0.408 s
16. Speed of a microwave of wavelength 5×10^{-3} m in a vacuum is 5×10^8 m s⁻¹, its frequency is equal to
- a. 1.5×10^5 Hz
 - b. 6×10^9 Hz
 - c. 1.5×10^6 Hz
 - d. 6×10^{10} Hz
17. Wave that does not belong to EM spectrum is
- a. Gamma rays
 - b. Radio waves
 - c. Sound waves
 - d. Infrared waves
18. The energy of an electromagnetic wave resides in its
- a. frequency
 - b. wavelength
 - c. speed
 - d. electric and magnetic fields
19. The Doppler effect occurs
- a. only in sound waves
 - b. only in longitudinal waves
 - c. only in transverse waves
 - d. in all types of waves
20. Which one of the following waves cannot travel through a vacuum?
- a. sound waves
 - b. radio waves
 - c. light waves
 - d. x-rays
21. Wave interference can occur for
- a. sound waves
 - b. light waves
 - c. water waves
 - d. all of these

22. The speed of any wave depends upon
- a. its energy
 - b. the medium through which it travels
 - c. its angle of reflection
 - d. its amplitude
23. The source of all sound waves is a
- a. wave pattern
 - b. harmonic object
 - c. vibrating object
 - d. none of these
24. A mass attached to a spring vibrates back and forth. At maximum displacement, the spring force and the
- a. velocity reach a maximum
 - b. acceleration reach a maximum
 - c. velocity reach zero
 - d. Acceleration reach zero.
25. For a mass hanging from a spring, the maximum displacement the spring is stretched or compressed from its equilibrium position is the system's
- a. amplitude
 - b. frequency
 - c. period
 - d. acceleration..
26. A spring with spring constant 5.5 k N/m is attached to a 9.8 gram mass. The maximum acceleration is 3.4 m/s^2 . What is the maximum displacement?
- a. $1.92 \times 10^{-7} \text{ m}$
 - b. $6.06 \times 10^{-7} \text{ m}$
 - c. $1.92 \times 10^{-6} \text{ m}$
 - d. $6.06 \times 10^{-6} \text{ m}$
27. A 0.156 kg mass is on a spring that causes the frequency of oscillation to be $95 \text{ cycles per second}$. The maximum velocity is 50.6 m/s . What is the maximum force on the mass?
- a. $2.2 \times 10^3 \text{ N}$
 - b. $1 \times 10^4 \text{ N}$
 - c. $4.7 \times 10^3 \text{ N}$
 - d. $2.2 \times 10^4 \text{ N}$
28. Displacement-time graph depicting an oscillatory motion is
- a. cos curve
 - b. tangent curve
 - c. sine curve
 - d. straight line

29. Natural frequency of a guitar string can be changed by changing it's
- a. area
 - b. length
 - c. diameter
 - d. stiffness
30. In SHM, velocity at equilibrium position is
- a. minimum
 - b. maximum
 - c. constant
 - d. zero
31. Over-damping results in
- a. slower return to equilibrium
 - b. equilibrium is never achieved
 - c. faster return to equilibrium
 - d. arrhythmic return to equilibrium
32. Oscillations become damped due to
- a. normal force
 - b. tangential force
 - c. friction
 - d. parallel force
33. A pendulum clock is observed to give correct time at the equator. What will happen if the same pendulum clock is taken to the pole of the earth?
- a. It will gain time
 - b. It will loss time
 - c. Unchanged
 - d. None of these
34. A mass on a spring undergoes SHM. It goes through 10 complete oscillations in 5.0 s. What is the period?
- a. $2.0s$
 - b. $0.20s$
 - c. $50s$
 - d. $0.50s$
35. The length of a simple pendulum executing simple harmonic motion is increased by 21%. The percentage increase in the time period of the pendulum of increased length is:
- a. 11%
 - b. 42%
 - c. 21%
 - d. 10%

[20 marks]

B. Problems: Answer the following questions.

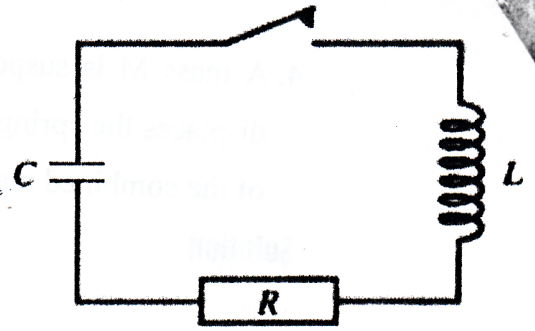
1. The H_2 molecule has a vibrational frequency ν of 1.32×10^{14} Hz. Calculate the strength of the molecular bond, i.e. the 'spring constant', assuming that the molecule can be modeled as a simple harmonic oscillator.

Solution

2. The electron in an excited atom behaves like a damped harmonic oscillator when the atom radiates light. The lifetime of an excited atomic state is 10^{-8} s and the wavelength of the emitted light is 500 nm. Deduce a value for the quality factor ($c = 3 \times 10^8$ m/s).

Solution

3. An electrical oscillator is shown in the attachment figure. It consists of an inductor L , capacitor C and a resistor R connected in series. Find an expression for the equation of a damped electrical oscillator.



Solution

4. A mass M is suspended from a light spring. If the additional mass m is added, displaces the spring by a distance x . Find an expression for time period of oscillation of the combined mass.

Solution

5. At $t = 0$, the displacement of a point $x(0)$ in a linear oscillator is -8.6 cm , its velocity $v(0) = -0.93 \text{ m/s}$ and its acceleration $a(0)$ is $+48 \text{ m/s}^2$. (a) What are the angular frequency ω and the frequency ν ? (b) What is the phase constant? (c) What is the amplitude of the motion?

Solution

[END OF EXAM]