

I- ONE Mark for each

ضع الحروف التي تشير الى الاجابات الصحيحة في الجدول (وضح تماماً الحروف)

- 1- On which of the following does the energy of a simple harmonic motion (SHM) depend
A) ω^2 B) $1/\omega^2$ C) $1/A^2$ D) A^2
(where ω is natural frequency and A is the amplitude)
- 2- What is the constant of proportionality of an oscillator if the damping force is directly proportional to the velocity
A) kg.s^{-1} B) kg.m.s^{-1} C) kg.s D) kg.m.s^{-2}
- 3- What is the change in the phase if a wave is reflected from a denser medium
A) 0 B) $\pi/2$ C) π D) 2π
- 4- What is the maximum acceleration of a particle in SHM with $\omega = \pi \text{ rad/s}$ and $A=1\text{m}$.
A) 9.87 J B) 10.87 J C) 11.87 J D) 12.87 J
- 5- Which of the following is true for the Gaussian pulse $y(x,t)=\exp[-(x-4t-5)^2]$?
A) The pulse travels with a velocity of 5 m/s in the positive x-direction.
B) The pulse travels with a velocity of 5 m/s in the negative x-direction.
C) The pulse travels with a velocity of 4m/s in the positive x-direction.
D) The pulse travels with a velocity of 4 m/s in the negative x-direction.
6. The incident wave amplitude is 24 units. Find the reflected wave amplitude if the reflection coefficient is 0.6
A) 40 B) 14.4 C) 1/40 D) 23.4
- 7- If an equation of motion is given by: $ma = -kx - bv$, what is the expression for amplitude of motion?
A) $A_0 e^{b/\gamma}$ B) $A_0 e^{-(\gamma/2)t}$ C) $A_0 e^{-\gamma t}$ D) $A_0 e^{-2\gamma t}$
- 8- A system with a damping constant (b), mass (m), and spring constant (k) is said to be critically damped if:
A) $b^2 < 4mk$ B) $b^2 > 4mk$ C) $b^2 = 0$ D) $b^2 = 4mk$

II- TWO Marks for each

- 9-A vertical sprig of spring constant 180 Nm^{-1} was elongated by 10 cm and left to oscillate. Calculate the kinetic energy of the oscillator at 8 cm from equilibrium.
A) 0.12 J B) 0.22 J C) 0.32 J D) 0.42 J

1	2	3	4	5	6	7	8	9

10- A simple pendulum of length L and periodic time T_1 is displaying SHM. If L is increased to $2L$. Calculate the periodic time T_2 of the pendulum.

- A) $T_2 = T_1/\sqrt{2}$ B) $T_2 = 2 T_1$ C) $T_2 = \sqrt{2} T_1$ D) $T_2 = T_1/2$

11- A circuit contains a capacitor of capacitance of 10^{-6} F and an inductor of 10^{-4} H. The frequency of electrical oscillation will be

- A) $(10^5/2\pi)$ Hz B) $(2\pi/10^5)$ Hz C) $(10^{-5}/2\pi)$ Hz D) $(2\pi/10^{-5})$ Hz

12- In LCR circuit consists of $L = 5$ H, $C = 15$ mF and $R = 900 \Omega$. The system is

- A) undamping B) critically damped C) heavy damped D) light damped

13- An observer hears a sound frequency f' . If the observer is moving with $(v/2)$ away from the stopped source. Determine the relation between f' and frequency f of the sound (where v is velocity of sound).

- A) $f' = 0.25 f$ B) $f' = 0.5 f$ C) $f' = f$ D) $f' = 2 f$

14- A wave traveling along a string is described by the function $y = 4 \cos(3.14 x + 3 t)$, where x and y are in meters and t is in seconds. Find the wavelength in meters.

- A) 2 B) 3 C) 4 D) 5

15- A spring of constant 100 N/m and mass of 4 kg moves in SHM under external force without damping. If $F_0 = 16$ N, determine the amplitude of oscillation at external frequency of 2 rad s^{-1}

- A) 0.49 m B) 0.39 m C) 0.29 m D) 0.19 m

16- A wave traveling along a string is described by the function

$y = 2 \cos(0.2 x + 30 t)$, where x and y are in meters and t is in seconds. Find

the velocity of the wave

- A) 200 m/s B) 150 m/s C) 100 m/s D) 50 m/s

17- An observer is in a car moving north at a speed of 20 m/s. An ambulance travels to the south at a speed of 30 m/s, its siren emits sound at frequency of 210 Hz. What will be the frequency as heard by the observer? The speed of sound in air is 330 m/s.

- A) 217 Hz B) 181 Hz C) 204 Hz D) 245 Hz

10	11	12	13	14	15	16	17

III- Four Marks for each

- 17) Draw the relations (energies versus time) and (energies versus position) for a spring with a simple harmonic oscillation. Write only the value of each energy.

- 18) Study the oscillation motion in the physical pendulum to get the form of its time period.

19) Deduce the ratio of two successive amplitudes in damped unforced oscillator.

20) If a stopped source emits waves, deduce the heard frequency by a moving radar:

i) toward the source.

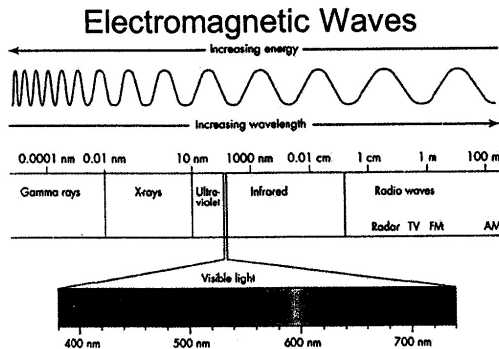
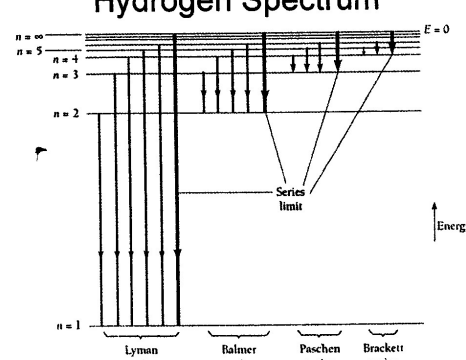
ii) away from the observer.

21) Calculate the transmission and reflection coefficient of amplitude for a wave travels from one medium to another if the mass of the unit length (μ) of the second medium is 4 times that of the first medium.

22) Deduce the wave equation in one dimension.

	Assiut University Faculty of Science Department of Physics Second Semester Final Exam (2025-2026)	Chem., Math., Geology & Other Related Program Level: (2) Date: May 23rd, 2026 Time: 2 hours	
Course Title: Principles of Modern Physics Instructor: Prof. Dr. Salah A. Makhlof			Code: P225
Important: 8 pages, Part One: 21 MCQs + Part Two: Answer 3 of the given 4 Qs			Total Marks: 50

Constants & Conversion of units

$Electron\ mass: m = 9.11 \times 10^{-31}\ kg\ \&\ Proton\ mass: m = 1.673 \times 10^{-27}\ kg$
$Electron\ charge: e = 1.6 \times 10^{-19}\ C$
$Planck's\ constant: h = 6.626 \times 10^{-34}\ J\cdot s\ and\ \hbar = 1.054 \times 10^{-34}\ J\cdot s$
$Avogadro's\ number: N_A = 6.02 \times 10^{23}\ atom/mole$
$Speed\ of\ light: c = 3 \times 10^8\ m/s$
$Boltzmann's\ constant: k_B = 1.38 \times 10^{-23}\ J/K$
$Compton\ wavelength: \lambda_c = 2.426\ pm$
$Rydberg\ Constant\ R = 1.097 \times 10^7\ m^{-1}$
$For\ hydrogen\ atom: Bohr\ radius\ a_0 = 5.292 \times 10^{-11}\ m\ \&\ E_{ion} = 13.6\ eV$
$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/N\ m^2$
$1\ eV = 1.6 \times 10^{-19}\ J$
$1\ \text{\AA} = 10^{-10}\ m\ \&\ 1\ nm = 10^{-9}\ m$
Electromagnetic Waves  Hydrogen Spectrum 

Part One) Choose the correct option for the following questions (1 Mark each) (20 Marks)

1. Max Planck proposed that energy is emitted in the form of:
 - a) Continuous waves
 - b) Discrete quanta
 - c) Electrons
 - d) Electromagnetic waves
2. In the photoelectric effect, if the light frequency is below the threshold frequency:
 - a) Electrons are emitted
 - b) The intensity increases
 - c) No electrons are emitted
 - d) X-rays are produced
3. The work function of a metal is:
 - a) The minimum energy to remove an electron
 - b) The maximum kinetic energy of an electron
 - c) The frequency of incident light
 - d) The mass of the electron
4. Above the threshold frequency, the stopping potential depends on:
 - a) Light intensity only
 - b) Light frequency
 - c) Type of ammeter used
 - d) Distance of the light source
5. In Compton scattering, the scattered photon has:
 - a) Longer wavelength than incident
 - b) Shorter wavelength
 - c) Same wavelength
 - d) Zero energy
6. The experiment of Clinton Davisson and Lester Germer confirmed:
 - a) Compton scattering
 - b) Electron diffraction
 - c) Photoelectric effect
 - d) Blackbody radiation
7. Matter waves become noticeable when the wavelength is:
 - a) Negligible
 - b) Comparable to the system size
 - c) Zero
 - d) Infinite
8. An electron microscope uses:
 - a) Shorter wavelength of electrons than light
 - b) Longer wavelength than light
 - c) Sound waves
 - d) X-rays only
9. $|\psi|^2$ gives the:
 - a) Exact momentum
 - b) Mass density
 - c) Charge density
 - d) Probability density
10. The uncertainty principle states that we cannot know simultaneously:
 - a) Energy and time with perfect accuracy
 - b) Position and momentum with perfect accuracy
 - c) Options a) and b) are both incorrect
 - d) Options a) and b) are both correct
11. Ernest Rutherford gold foil experiment showed that:
 - a) Atoms are solid spheres
 - b) Positive charge is concentrated in a tiny nucleus
 - c) Electrons are inside the nucleus
 - d) Atoms are indivisible

12. In the Bohr model, electrons move in:
- Random paths
 - Circular orbits with unquantized angular momentum
 - Circular orbits with quantized angular momentum
 - Elliptical orbits like planets
13. The ionization energy is the energy needed to:
- Add an electron
 - Excite an electron
 - Split the nucleus
 - Remove an electron completely
14. The process responsible for laser action is:
- Photoelectric emission
 - Stimulated emission
 - Spontaneous emission
 - Compton scattering
15. Population inversion in a laser means:
- More atoms are in the ground state
 - More atoms are in an excited state than in a lower-energy state
 - Atoms lose all their electrons
 - Equal numbers of atoms are in all states
16. According to Albert Einstein, one postulate of special relativity states that:
- Time is absolute
 - The speed of light is constant for all observers
 - Mass is always constant
 - Energy is conserved only in moving frames
17. Length contraction occurs in the direction:
- Perpendicular to motion
 - Parallel to motion
 - Nonparallel to motion
 - In all directions equally
18. A light-year is a unit of:
- Time
 - Speed
 - Energy
 - Distance
19. According to the first postulate of special relativity, the laws of physics are the same in all:
- Accelerating frames
 - Rotating frames
 - Inertial frames
 - Frames with high gravitational fields
20. The relativistic factor γ (gamma) becomes large when:
- $v \ll c$
 - v approaches c
 - $v = c/2$
 - $v = 0$
21. Relativistic momentum compared to classical momentum is:
- Always larger
 - Always smaller
 - The same at all speeds
 - Zero for photons

Part Two: Answer Three (3) only of the following questions (10 Marks each) (30 Marks)
Q1) (10 Marks)

1. A spaceship travels at $v = 0.6c$ relative to Earth. (Each point is worth 2 marks)
- a) The spaceship's clock measures a trip duration of $t_0 = 8 \text{ years}$. How much time (t) passes on Earth?
 - b) The spaceship has a rest length of $L_0 = 40 \text{ m}$. What length (L) do Earth observers measure?

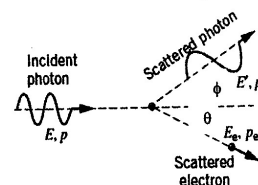
2. A π^+ pion moves at $v = 0.96c$. (for π^+ pion: $m_0c^2 = 139.6 \text{ MeV}$). (Each point is worth 2 marks)
- a) Calculate the Lorentz factor γ ?
 - b) Find the kinetic energy (KE) of the π^+ pion in MeV ?
 - c) Find the total energy (E) of the π^+ pion in MeV ?

Q2)

(10 Marks)

An X-ray photon of wavelength $\lambda = 0.100 \text{ nm}$ is scattered by a stationary free electron. The photon is scattered at an angle of $\phi = 90^\circ$ relative to its incident direction.
(Each point is worth 2 marks)

- What is the wavelength shift $\Delta\lambda$ of the photon?
- What is the new wavelength λ' of the scattered photon?
- How much energy (in eV) does the photon lose in this scattering event?
- What is the kinetic energy of the recoiling electron (in eV)?
- If the scattering angle were changed to $\phi = 180^\circ$ (backscattering), would the wavelength shift be larger or smaller than for 90° ? Explain briefly.



Q3)**(10 Marks)**

An electron is confined to a one-dimensional box of length $L = 2 \times 10^{-10} \text{ m}$. (Each point is worth 2 marks)

- a) Calculate the ground state energy ($n = 1$) in eV?
- b) What is the energy of the first excited state ($n = 2$) in eV?
- c) If the electron drops from $n = 2$ to $n = 1$, what is the wavelength of the emitted photon? In which region of the EM spectrum does it lie?
- d) For the electron in the ground state ($n = 1$), where is the probability of finding it is maximum (i.e., from $x = 0$ to $x = L$)?
- e) How would the de Broglie wavelength of the electron in the $n = 1$ state change if the box length is reduced to $\frac{L}{2}$. (Qualitative answer is fine)?

Marks of

(10 Marks)

Q4)

(Each point is worth 2 marks)

For the hydrogen atom, use $E_n = -\frac{13.6}{n^2} \text{ eV}$.

- a) Calculate the energy (in eV) of the photon emitted when an electron in hydrogen drops from $n = 3$ to $n = 2$?
- b) To which spectral series does this photon belong?
- c) What is its wavelength (in nm) and frequency (in Hz) of this photon?
- d) Is it in the visible region? Explain why?
- e) In the Bohr model, the orbital speed of the electron in the ground state ($n = 1$) is $v_1 = 2.19 \times 10^6 \text{ m/s}$. What is the orbital speed of the electron in the $n = 2$ state? (Hint: $v_n \propto 1/n$)



Assiut University
Faculty of Science
Department of Physics
Second semester 31/5/2026

Course: Modern Physics
Code: P215
Time: 3 Hour
Final Exam 50%



The exam is written in twelve (12) pages

Answer five (5) only of the following questions:

(10 Marks)

Question (1):

(2 Marks)

a) Put (✓) or (✗):

1-	To prove the assumption $L_n = m\omega r^2$, Bohr employed the correspondence principle, which states that "as the quantum number n becomes very large, the predictions of quantum physics converge with those of classical physics".	
2-	In Compton scattering, scattered photon has smaller wavelength than the incident one.	
3-	Pair production cannot take place in empty space.	
4-	Maxwell's equations are covariant under Galilean transformation.	

- b) If we considered the Sun as a black-body, 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.

(4 Marks)

- c) State the Lorentz-Einstein transformations.
Using those transformations, deduce the relativistic velocity Lorentz transformations. (4 Marks)

Question (2):**(10 Marks)**

a- Choose the correct statement:

(2 Marks)

Please write your selections (a or b or ...) in the blank column to the right of the table.

1-	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.
2-	According to the Heisenberg uncertainty principle, if the position of a moving particle is known, what other quantity cannot be known?			
	a- mass.	b- charge.	c- spin.	d- velocity.
3-	When an electron moves from a lower to a higher energy level, the electron			
	a- always doubles its energy.		b- emits a quantum of energy.	
	c- absorbs a quantum of energy.		d- moves closer to the nucleus.	
4-	An electron moves through the lab at 99% the speed of light. The lab reference frame is S and the electron's reference frame is S'. In which reference frame is the electron's proper mass larger?			
	(a) Frame S, the lab frame.		(b) Frame S', the electron's frame.	
	(c) It is the same in both frames.		(d) impossible to measure.	

b- Light of wavelength 400 nm is incident upon lithium; the work function for the lithium ($\phi = 2.93 \text{ eV}$). Calculate

- The photon energy.
- The stopping potential V_0 .
- The kinetic energy of the fastest of the emitted electrons.
- The velocity of the fastest of the emitted electrons.

(4 Marks)

c- Derive the relation between the total energy E and the relativistic momentum p . (4 Marks)

c- Derive the relation between the total energy E and the relativistic momentum p . (4 Marks)

Question (3):

(10 Marks)

a) Put (✓) or (✗):

(2 Marks)

1-	The relativistic Doppler shift equation, unlike the Doppler shift equation for sound, depends only on the relative speed v of the source and observer and holds for relative speeds as great as c .	
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-	Michelson-Morley Experiment proved the presence of ether.	
4-	The minimum wavelength $\lambda_{\min}$ of X-rays depend on the kind of the metal target.	

b- Prove the Duane-Hunt law, which gives the minimum wavelength $\lambda_{\min}$ 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.

(4 Marks)

- c- A train with a proper length of 15 meters moves at a speed of $0.8c$ toward a 10-meter-long underground tunnel. The tunnel is equipped with front and rear gates that are normally open. A ground observer closes both gates simultaneously the moment the train is entirely within the tunnel and then immediately reopens them. Do both the ground observer and the train driver agree that the train passes through the tunnel safely? Enhance your answer using space-time graphs. (4 Marks)

Question (4):**(10 Marks)****(2 Marks)**

a- Choose the correct statement:

Please write your selections (a or b or ...) in the blank column to the right of the table.

Please write your solution in the space provided.

1-	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.			
2-	A large constant force is used to accelerate an object from rest to a high speed. In which form of Newton's second law—relativistic or classical nonrelativistic—does the object take a longer time to reach a speed of $0.9c$?			
	(a) Relativistic.		(b) Nonrelativistic.	
	(c) Same for both.		(d) impossible to measure	
3-	For a material object, such as a rocket ship, the possible range of γ_v is			
	(a) $0 \leq \gamma_v \leq 1$	(b) $1 \leq \gamma_v$	(c) $0 < \gamma_v < \infty$	(d) $-\infty < \gamma_v < \infty$
4-	In the Bohr model of the hydrogen atom, by increasing the quantum number, the energy difference between any two successive levels in the atom			
	(a) increasing		(b) be equal	
	(c) decreasing		(d) none of the preceding	

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 wavelengths of the X-ray scattered at a 30° angle. **(4 Marks)**

c- Define the proper mass, and prove the fact that, any particle having zero proper mass "such as photon" always move with speed of light c . (4 Marks)

Question (5):

(10 Marks)

a) Put (✓) or (✗):

(2 Marks)

1-	Rutherford's model destroyed by the electromagnetic theory.	
2-	Heisenberg's uncertainty principle says "It impossible to measure simultaneously the position and the momentum of a particle".	
3-	The proper time is always the shortest time interval.	
4-	In photoelectric effect, the maximum kinetic energy of photoelectrons depends on the intensity of incident EM waves.	

- b- An enemy spaceship is moving toward your starfighter with a speed of $0.4c$, as measured in your reference frame. The enemy ship fires a missile toward you at a speed of $0.7c$ relative to the enemy ship, as in the Figure.



- What is the speed of the missile relative to you? Express your answer in terms of the speed of light.
- If you measure the enemy ship to be $8.0 \times 10^6 \text{ km}$ away from you when the missile is fired, how much time, measured in your frame, will it take the missile to reach you?
- What if you manage to evade the missile, and the missile overtakes your starfighter? What would the missile's speed be relative to you?

- c- Bohr's model failed to explain the fine structure of the hydrogen atom's spectrum, explain that, and discuss the Sommerfeld's modification to overcome this deficiency. Explaining the energy level schemas before and after modification, and clarifying the selection rule. (4 Mark)

(10 Marks)

Question (6):

(2 Marks)

- a- Choose the correct statement:
Please write your selections (a or b or ...) in the blank column to the right of the table.

1-	A spaceship leaves Earth and maintains a constant force by means of a nuclear engine. As the speed of the spaceship increases, an observer on Earth finds that relative to her the magnitude of the spaceship's acceleration is			
	(a) 0	(b) decreasing.	(c) constant.	(d) increasing.
2-	Light of frequency 1.9 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes			
	(a) quadrupled	(b) doubled	(c) halved	(d) zero
2-	What is the effect of doubling the accelerating voltage across an x-ray tube?			
	(a) the wavelengths of the characteristic lines are halved			
	(b) the minimum wavelength of the X-rays is halved			
	(c) the X-rays are most probably less penetrating			
	(d) the intensity of the X-ray beam is doubled			
4-	If it requires energy U to accelerate a rocket from rest to $0.5c$, the energy needed to accelerate that rocket from $0.5c$ to c would be			
	(a) $0.5U$	(b) U	(c) $2U$	(d) infinite

- b- The kinetic energy of an electron is equal to twice its rest energy, calculate:
Its relativistic momentum?
The de Broglie wavelength?

(4 Marks)

- c) Discuss The Franck-Hertz experiment which provides empirical evidence for the quantization of atomic energy levels. (4 Marks)

Electron charge e	$1.6 \times 10^{-19} \text{ C}$	Plank's constant h	$6.626 \times 10^{-34} \text{ Joul.sec}$
Electron mass m_e	$9.1 \times 10^{-31} \text{ kg}$	Light velocity c	$2.998 \times 10^8 \text{ m.sec}^{-1}$
Wien's displacement constant	$2.8977 \times 10^{-3} \text{ m.K}$	Ionization energy of the hydrogen atom E_0	13.6 eV



Assiut University - Faculty of Science
First Semester - Final Exam 2025-2026
Physics Department

Programs:
- Mathematics
- Statistics
- Computer Science
Level : (2)
Date: 7/6/2026
Time: 2 h



Course Title: Electricity and AC circuits			Code: P226
Important:	No. of pages: 6	No. of questions: 2	Total Mark: 50 Marks
Instructor: Prof. Dr. Hicham Mahfouz Kotb Mahfouz			

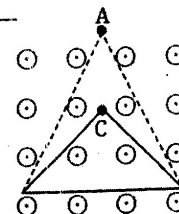
Q1: Circle clearly the correct answer for the following questions: (Total 20 Marks: 1 mark for each of the points 1-11 and 1.5 marks for each of the points 12-17)

1. Which of the following is Faraday law?

- (a) $\vec{B} = \mu_0 n \vec{I}$ (b) $\varepsilon = -N \frac{d\Phi_B}{dt}$ (c) $\vec{F} = I \vec{\ell} \times \vec{B}$ (d) $L = N\Phi_B/I$

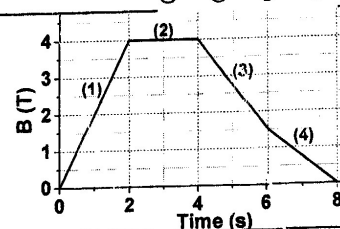
2. A flexible triangle lies in a uniform magnetic field that is directed out of the page as illustrated. As the vertex of the triangle is pushed upward from point C to point A, what is the direction of the current induced in the triangular loop?

- (a) Clockwise (b) Counter-clockwise
(c) Oscillating (d) Current is zero



3. The graph shows the magnitude of a time varying uniform magnetic field B that is perpendicular to the plane of a conducting loop. During which of the five regions indicated on the graph, the magnitude of the emf induced in the loop will be zero.

- (a) region 1 (b) region 2
(c) region 3 (d) region 4



4. The total energy in a circuit contains a resistor, inductor and capacitor with time.

- (a) is constant (b) decreases (c) increases (d) oscillates

5. Eddy currents are often undesirable because they transform part of the mechanical energy into internal energy. True or False?

- (a) True (b) False

6. Both $[N\Phi_B/I]$ and $[\varepsilon/(dI/dt)]$ have the same units of

- (a) Ohm (b) Volt (c) Farad (d) Henry

7. A steady current flows through a circuit with a large inductive time constant. When a switch in the circuit is suddenly opened, a large spark occurs across the terminals of the switch. True or False?

- (a) True (b) False

8. Wireless charging in cordless devices uses the of solenoids as part of its battery-charging system.

- (a) eddy currents (b) self-induction (c) mutual induction (d) resonance

9. In a pure capacitive AC circuit if the source frequency is reduced to to one-half of its original value, the current will

- (a) be reduced by half (b) be doubled
(c) be four times as high (d) be reduced to one fourth

Δ Remember ■ Understand • Apply ◇ Analyze * Evaluate ○ Create

Which of the following increases the magnetic energy density in the interior of a very long solenoid?

- (a) increasing the number of turns per unit length on the solenoid
- (b) increasing the cross-sectional area of the solenoid
- (c) increasing only the length of the solenoid while keeping the number of turns per unit length fixed
- (d) decreasing the current in the solenoid

11. In an RC circuit, the time required for a capacitor to discharge completely _____ as the resistance decreases.

- (a) increases
- (b) decreases
- (c) remains constant
- (d) doubles

12. A car with a radio antenna 1 m long travels at 20 m/s in a locality where the Earth's magnetic field is 5×10^{-5} T. What is the maximum possible emf induced in the antenna as a result of moving through the Earth's magnetic field?

- (a) 1 mV
- (b) 40 mV
- (c) 16 mV
- (d) 115 mV

13. An AC generator consists of 500 turns of wire loop, each of area 300 cm^2 . The loop rotates in a 50 mT magnetic field. At what frequency should the loop rotate to have a maximum value of the induced emf equal to 220 V?

- (a) 293.3 Hz
- (b) 220.0 Hz
- (c) 46.7 Hz
- (d) 16.5 Hz

14. An emf of 96 mV is induced in the windings of a coil when the current in a nearby coil is increasing at the rate of 1.2 A/s. What is the mutual inductance of the two coils?

- (a) 0.11 mH
- (b) 48 mH
- (c) 96 mH
- (d) 80 mH

15. Radio receivers are usually tuned by adjusting the capacitor of an LC circuit. If $C = C_1$ for a frequency of 600 kHz, then for a frequency of 1200 kHz one must adjust C to:

- (a) $0.5C_1$
- (b) $0.25C_1$
- (c) $2C_1$
- (d) $4C_1$

16. If the current through a 1- mH inductor is varying with time as: $I_L = 2t$, what is the voltage across it?

- (a) 1 mV
- (b) 1.5 mV
- (c) 2 mV
- (d) 0 mV

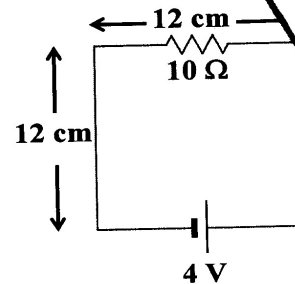
17. When a switch is closed, completing an LR series circuit, the time needed for the current to reach 63.2% of its maximum value istime constants.

- (a) 0.25
- (b) 0.50
- (c) 1.00
- (d) 1.35

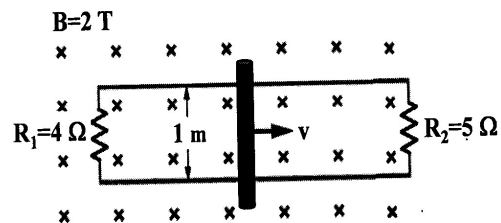
Q2. Solve the following problems. Show all your work:

(30 Marks)

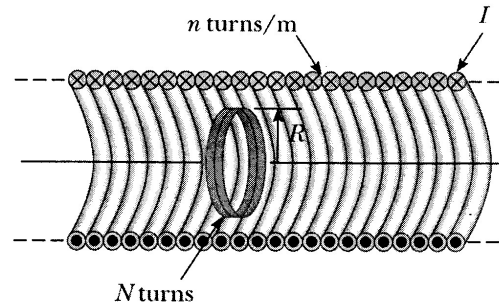
1. A circuit (shown in the figure) lies in a uniform magnetic field that is directed out of the page. The magnetic field is decreasing at a rate of 150 T/s . Determine the direction and value of the current in the circuit?
(4 marks)



2. The rod shown below moves to the right on two parallel conducting rails at a speed of $v=10.0 \text{ m/s}$. If $B=2.0 \text{ T}$ everywhere in the region. Determine the value and indicate the direction of the current through each of the resistors R_1 ($4.0\text{-}\Omega$) and R_2 ($5.0\text{-}\Omega$)?
(3 marks)

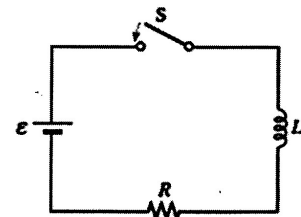


3. A long solenoid has $n=400$ turns per meter and carries a current given by $I=3.0$ A. Inside the solenoid and coaxial with it is a coil that has a radius $R=6.0$ cm and consists of a total of $N=250$ turns of fine wire. Calculate the mutual inductance M . [Hint: $\mu_0=4\pi\times10^{-7}$ T.m/A] (3 marks)



4. Consider the circuit in the shown Figure, taking $\varepsilon = 6.0$ V, $L = 8.0$ mH, and $R = 4.0$ Ω .

- (a) What is the inductive time constant of the circuit? (1.5 marks)



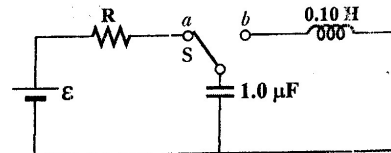
- (b) Calculate the current in the circuit 250 μ s after the switch is closed. (2 marks)

- (c) What is the value of the final steady-state current? (1.5 marks)

5. that the maximum instantaneous current in the LC circuit is 0.10 A. Calculate the following: switch in the shown circuit is connected to point -a- for a long time. After the switch is thrown point -b-, it was observed:

(a) The value of the maximum potential difference across the capacitor.

(2.5 marks)



(b) The frequency of oscillations in the current.

(1.5 marks)

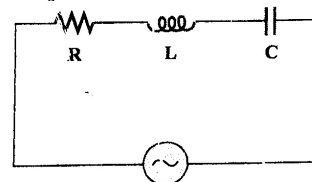
(c) The total energy the LC circuit possesses at $t=3.0$ s after switching to position b.

(1 mark)

6. A series RLC circuit, driven with $\Delta V_{\text{rms}}=120$ V at frequency of 60.0 Hz, contains a resistance $R=200\ \Omega$, an inductance with inductive reactance $X_L=80.0\ \Omega$, and a capacitance with capacitive reactance $X_C=150\ \Omega$.

(a) What is the phase constant ϕ of the circuit?

(2 marks)



(b) Draw the phasor diagram for the applied voltage and the current of the circuit. Indicate clearly which quantity leads and which lags.

(2 marks)

(c) What is the power factor of the circuit?

(1.5 mark)

(d) Calculate the average power P_{avg} delivered to this circuit.

(2 marks)

(e) What new capacitance C_{new} is needed for the P_{avg} to reach its maximum value if the other parameters of the circuit are not changed?

(2.5 marks)

End of Exam

Best Wishes
Prof. Dr. Hicham Mahfoz Kotb



Answer all the following questions

Question (I): In the following multiple-choice questions, please circle the correct answer(s). You must write down the steps to get the correct answer if needed (26 Marks)

- The atomic packing factor for SC is:
a. 74% b. 68% c. 63% d. 52%
- Calculate the radius of a vanadium atom, given that vanadium has a BCC crystal structure, a density of 5.96 g/cm³, and an atomic weight of 50.9 g/mol ($N_A = 6.022 \times 10^{23}$ atoms/mol).
a. 0.124 nm b. 0.132 nm c. 0.148 nm d. 0.156 nm
- Rhodium has an atomic radius of 0.1345 nm, a density of 12.41 g/cm³, and an atomic weight of 102.91 g/mol. Its crystal structure should be:
a. SC b. FCC c. BCC d. HCP
- Zinc has an HCP crystal structure, c/a ratio of 1.856, and a density of 7.13 g/cm³. Compute the atomic radius for Zinc:
a. 0.133 nm b. 0.142 nm c. 0.153 nm d. 0.167 nm
- The atomic radius for tungsten is 0.137 nm; tungsten has a BCC crystal structure, therefore, the linear density for the [111] direction is:
a. 2.46 nm⁻¹ b. 1.42 nm⁻¹ c. 2.23 nm⁻¹ d. 3.65 nm⁻¹
- The atomic radius for nickel is 0.125 nm, nickel has an FCC crystal structure, therefore, the planar density for the (111) plane is:
a. 16.00 nm⁻² b. 18.48 nm⁻² c. 19.20 nm⁻² d. 20.56 nm⁻²
- Molybdenum has a BCC crystal structure and an atomic radius of 0.1363 nm, the interplanar spacing d_{111} equals:
a. 0.1817 nm b. 0.1432 nm c. 0.1527 nm d. 0.1707 nm
- Determine the expected diffraction angle (2θ) for the first-order reflection from the (113) set of planes for FCC platinum ($R=0.1387$ nm) when monochromatic radiation of wavelength 0.1542 nm is used:
a. 81.38° b. 76.31° c. 38.85° d. 17.88°
- For which set of crystallographic planes will a first-order diffraction peak occur at a diffraction angle (2θ) of 46.21° for BCC iron ($R=0.1241$ nm) when monochromatic radiation having a wavelength of 0.0711 nm is used?
a. (011) b. (310) c. (200) d. (330)
- Calculate the number of vacancies per cubic meter in iron at 850 °C. The energy for vacancy formation is 1.08 eV/atom. Furthermore, the density and atomic weight for iron are 7.65 g/cm³ and 55.85 g/mol, respectively, ($K_B = 8.62 \times 10^{-5}$ eV/atom K):
a. $1.17 \times 10^{24} \text{ m}^{-3}$ b. $2.2 \times 10^{25} \text{ m}^{-3}$ c. $2.75 \times 10^{26} \text{ m}^{-3}$ d. $3.40 \times 10^{28} \text{ m}^{-3}$
- The concentration of carbon in an iron-carbon alloy is 0.15 wt%. What is the concentration in kilograms of carbon per cubic meter of alloy? (The density of carbon is 2.25 g/cm³, and the density of iron is 7.87 g/cm³)
a. 11.80 kg/m³ b. 9.72 kg/m³ c. 7.33 kg/m³ d. 2.48 kg/m³
- Gold (196.97 g/mol) forms a substitutional solid solution with silver (107.87 g/mol). Compute the number of gold atoms per cubic centimeter for a silver-gold alloy that contains 10 wt% gold and 90 wt% silver. The densities of pure gold and silver are 19.32 g/cm³ and 10.49 g/cm³, respectively.
a. 7.36×10^{21} b. 5.66×10^{21} c. 3.36×10^{21} d. 1.44×10^{21}
- A plate of iron is exposed to a carburizing (carbon-rich) atmosphere on one side and a decarburizing (carbon-deficient) atmosphere on the other side at 700 °C. If a condition of steady state is achieved, calculate the diffusion flux of carbon through the plate if the concentrations of carbon at positions of 5 and 10 mm (5×10^{-3} and 10^{-2} m) beneath the carburizing surface are 1.2 and 0.8 kg/m³, respectively. Assume a diffusion coefficient of $3 \times 10^{-11} \text{ m}^2/\text{s}$ at this temperature.
a. $2.8 \times 10^{-3} \text{ kg/m}^2\cdot\text{s}$ b. $1.4 \times 10^{-7} \text{ kg/m}^2\cdot\text{s}$ c. $5.8 \times 10^{-8} \text{ kg/m}^2\cdot\text{s}$ d. $2.4 \times 10^{-9} \text{ kg/m}^2\cdot\text{s}$

Question (II): Answer the following problems

(12 Marks)

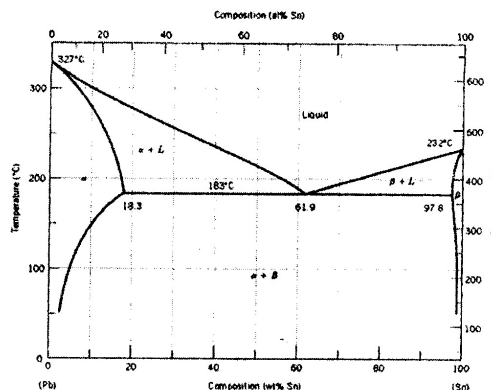
1. Silver (Ag) and palladium (Pd) both have the FCC crystal structure, and Pd forms a substitutional solid solution for all concentrations at room temperature. Compute the unit cell edge length for a 75 wt% Ag–25 wt% Pd alloy. The room-temperature density of Pd is 12.02 g/cm³, and the density of Ag is 10.49 g/cm³, while the atomic weight for Pd and Ag is 106.4 g/mol and 107.9 g/mol, respectively.
2. At 300 °C, the diffusion coefficient and activation energy for Cu in Si are $D(300\text{ °C}) = 7.8 \times 10^{-11} \text{ m}^2/\text{s}$ and $Q_d = 41.5 \text{ kJ/mol}$. What is the diffusion coefficient at 350°C? (Hint: $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)
3. Calculate the fraction of atom sites that are vacant for the lead at its melting temperature of 327°C (600 K). Assume energy for vacancy formation of 0.55 eV/atom.
4. The unit cell for tin has tetragonal symmetry, with a and b lattice parameters of 0.583 and 0.318 nm, respectively. If its density, atomic weight, and atomic radius are 7.30 g/cm³, 118.69 g/mol, and 0.151 nm, respectively, compute the atomic packing factor.
5. Titanium (Ti) has an HCP unit cell for which the ratio of the lattice parameters c/a is 1.58. If the radius of the Ti atom is 0.1445 nm, (a) determine the unit cell volume, and (b) calculate the density of Ti and compare it with the literature value (4.51 g/cm³). [Hint: $A_{\text{Ti}} = 47.87 \text{ g/mol}$; $N_A = 6.22 \times 10^{23} \text{ atoms/mol}$].
6. A piece of copper originally 305 mm long is towed in tension with a stress of 276 MPa. If the deformation is entirely elastic, what will be the resultant elongation? (Hint: Elastic modulus for copper is 110 GPa).

Question (III):

(6 Marks)

For a 40 wt% Sn–60 wt% Pb alloy at 100°C, in attached phase diagram:

- (a) What phase(s) is (are) present?
- (b) What is (are) the composition(s) of the phase(s)?
- (c) Calculate the relative amount of each phase present in terms of a mass fraction.
- (d) State the name, chemical formula, and temperature of the invariant reaction at 61.9 wt% Sn.
- (e) Investigate the microstructure for slow cooling from 300 °C to 100 °C for 61.9 wt% Sn composition.



Question (IV):

(6 Marks)

- (a) Determine the Miller indices for planes A, B, and C in the cubic unit cell shown in Figure 1.
- (b) Determine the indices of three directions from the cubic unit cell shown in Figure 2.

Figure 1

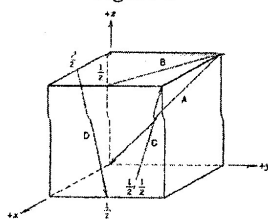
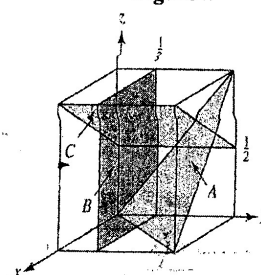


Figure 2



BEST WISHES,,,

I- ONE Mark for each

ضع الحروف التي تشير الى الاجابات الصحيحة في الجدول (وضح تماماً الحروف)

1- On which of the following does the energy of a simple harmonic motion (SHM) depend

- A) ω^2 B) $1/\omega^2$ C) $1/A^2$ D) A^2

(where ω is natural frequency and A is the amplitude)

2- What is the constant of proportionality of an oscillator if the damping force is directly proportional to the velocity

- A) kg.s^{-1} B) kg.m.s^{-1} C) kg.s D) kg.m.s^{-2}

3- What is the change in the phase if a wave is reflected from a denser medium

- A) 0 B) $\pi/2$ C) π D) 2π

4- What is the maximum acceleration of a particle in SHM with $\omega = \pi \text{ rad/s}$ and $A=1\text{m}$.

- A) 9.87 J B) 10.87 J C) 11.87 J D) 12.87 J

5- Which of the following is true for the Gaussian pulse $y(x,t)=\exp[-(x-4t-5)^2]$?

- A) The pulse travels with a velocity of 5 m/s in the positive x-direction.
B) The pulse travels with a velocity of 5 m/s in the negative x-direction.
C) The pulse travels with a velocity of 4m/s in the positive x-direction.
D) The pulse travels with a velocity of 4 m/s in the negative x-direction.

6. The incident wave amplitude is 24 units. Find the reflected wave amplitude if the reflection coefficient is 0.6

- A) 40 B) 14.4 C) 1/40 D) 23.4

7- If an equation of motion is given by: $ma = -kx - bv$, what is the expression for amplitude of motion?

- A) $A_0 e^{b/\gamma}$ B) $A_0 e^{-(\gamma/2)t}$ C) $A_0 e^{-\gamma t}$ D) $A_0 e^{-2\gamma t}$

8- A system with a damping constant (b), mass (m), and spring constant (k) is said to be critically damped if:

- A) $b^2 < 4mk$ B) $b^2 > 4mk$ C) $b^2 = 0$ D) $b^2 = 4mk$

II- TWO Marks for each

9-A vertical spring of spring constant 180 Nm^{-1} was elongated by 10 cm and left to oscillate. Calculate the kinetic energy of the oscillator at 8 cm from equilibrium.

- A) 0.12 J B) 0.22 J C) 0.32 J D) 0.42 J

1	2	3	4	5	6	7	8	9