



JOINT UNIVERSITIES PRELIMINARY EXAMINATIONS BOARD
SEPTEMBER 2021 EXAMINATIONS

PHYSICS

Time Allowed: 3 hours

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer all questions in this section.

Use the OMR answer sheet provided to answer the questions.

Follow the instructions on the OMR sheet.

SECTION B: ESSAY QUESTIONS

Answer **FOUR** questions; **ONE** question from each course.

Ensure you read and follow all the Instructions on the cover page of the Answer Booklet.

The following constants are given

Acceleration due to gravity, g	9.8 m/s^2
Atomic mass unit, u	$931.5 \text{ MeV} = 1.661 \times 10^{-27} \text{ kg}$
Avogadro's number, N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$
Boltzmann constant, k	$1.38 \times 10^{-23} \text{ J/K}$
Density of water, ρ_w	1000 kg/m^3
e/m	$1.76 \times 10^{11} \text{ C kg}^{-1}$
Electric charge, e	$1.6 \times 10^{-19} \text{ C}$
Electron rest mass, m_e	$9.11 \times 10^{-31} \text{ kg}$
Electron volt, eV	$1.602 \times 10^{-19} \text{ J}$
Gravitational constant, G	$6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
Mass of Helium nucleus	$4.0015u$
Mass of neutron	$1.0087u$
Molar gas constant, R	8.31 J/K/mol
Permeability of free space (μ_0)	$4\pi \times 10^{-7} \text{ Hm}^{-1}$
Permittivity of free space (ϵ_0)	$8.85 \times 10^{-12} \text{ F/m}$
Planck's constant, h	$6.6 \times 10^{-34} \text{ Js}$
Proton rest mass, m_p	$1.67 \times 10^{-27} \text{ kg}$
Radius of the earth, R	$6.4 \times 10^6 \text{ m}$
Refractive index for glass	1.5
Refractive index for water	1.33
Speed of light in vacuum, c	$3.0 \times 10^8 \text{ m/s}$
Stefan constant, σ	$5.67 \times 10^{-8} \text{ W/(m}^2\text{k}^4)$
Wien constant, α	$2.9 \times 10^{-3} \text{ mK}$
$(4\pi\epsilon_0)^{-1}$	$9.0 \times 10^9 \text{ mF}^{-1}$
1 atm	$1.105 \times 10^5 \text{ Pa}$

SECTION A: MULTIPLE CHOICE QUESTIONS.

Answer ALL questions.

1. A rock is thrown straight upward with an initial velocity of 24.5 m/s where the downward acceleration due to gravity is 10.0 m/s^2 . What is the rock's displacement after 1.0 s ?
 A. 9.81 m
 B. 19.5 m
 C. 24.5 m
 D. 29.4 m
2. Which of the following is the BEST statement of Pascal's Law?
 A. Pressure on a confined liquid is transmitted equally in all directions.
 B. The pressure of a given volume of gas is directly proportional to its temperature.
 C. The pressure at the top and bottom of a fluid are the same.
 D. The volume of a gas is directly related to its temperature.

3. The period of a spring-mass system undergoing simple harmonic motion is T . If the amplitude of the spring - mass system's motion is doubled, the period will be
 - A. $\frac{1}{4} T$
 - B. $\frac{1}{2} T$
 - C. T
 - D. $2T$
4. What is the average translational kinetic energy of nitrogen molecules at 1600 K?
 - A. $1.31 \times 10^{-20} \text{ J}$
 - B. $2.31 \times 10^{-20} \text{ J}$
 - C. $3.31 \times 10^{-20} \text{ J}$
 - D. $4.31 \times 10^{-20} \text{ J}$
5. What is the critical angle of light passing from a material of index of refraction 1.54 to a material of index of refraction $n = 1.33$?
 - A. 0°
 - B. 59.7°
 - C. 55.7°
 - D. 90.0°
6. An object with a mass of 5 kg displaces 350 ml of water. Which of the following is true?
 - A. The weight of this object is 50 N.
 - B. The weight of this object is 7 N.
 - C. The weight of this object is 3 N.
 - D. The buoyant force on this object is 3 N.
7. If the earth is considered as a sphere of radius r and density ρ , the gravitational intensity at the surface is given as $g = \frac{kr\rho}{r}$ where k is a constant, then the dimension of k is
 - A. MLT^{-2}
 - B. ML^{-1}T^1
 - C. ML^{-3}T^2
 - D. $\text{M}^{-1}\text{L}^3\text{T}^{-2}$
8. Water is flowing in pipe, P_1 of radius r , length L under a pressure difference at the two ends. If the flow rate has to be maintained for a pipe P_2 of radius $2r$, determine the length of pipe P_2 .
 - A. $2L$
 - B. $8L$

- C. 4L
- D. 16L

9. A projectile 'C' is fired at an angle of 50° above the horizontal; a projectile 'D' is fired with the same speed at an angle of 40° above the horizontal. Assuming a level ground and negligible air resistance, which of the following is true?
- A. 'C' will reach a greater height and have a greater range than 'D'.
 - B. 'C' will reach a greater height and have the same range as 'D'.
 - C. 'C' will reach a greater height and have a shorter range than 'D'.
 - D. 'C' will reach the same height and have the same range as 'D'.
10. If the earth is assumed to be a uniform sphere of radius 6.4×10^6 m and mass 6.0×10^{24} kg. Calculate the gravitational field strength at a point on the surface.
- A. 6.67 m/s^2
 - B. 9.77 m/s^2
 - C. 8.76 m/s^2
 - D. 4.34 m/s^2
11. A boy of mass 4 kg climbs flight of stairs 20 m in 30 seconds. Calculate the work done per second.
- A. 26.67 Js^{-1}
 - B. 53.33 Js^{-1}
 - C. 46.67 Js^{-1}
 - D. 35.33 Js^{-1}
12. The rate of change of momentum is directly proportional to the applied force and acts in the direction of the force. This is a statement of
- A. Newton's first law of motion.
 - B. Newton's second law of motion.
 - C. Gravitational law of attraction.
 - D. Kepler's law of planetary motion.
13. A beaker is filled with water at 4°C . At one time the temperature is increased by few degrees above 4°C and at another time it is decreased by a few degrees below 4°C . Which of the following is correct?
- A. The level of water remains constant in each case.
 - B. In first case water overflows while in second case its level reduces.

- C. In second case water overflows while in first case its level reduces.
- D. Water overflows in both cases.
14. 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. 40 cm
 - B. 50 cm
 - C. 30cm
 - D. 20 cm
15. An automobile tire has a volume of $1.64 \times 10^{-2} \text{ m}^3$ and contains air at a gauge pressure of 165kPa when the temperature is 0°C . What is the gauge pressure of the air in the tires when its temperature rises to 27.0°C and its volume increases to $1.67 \times 10^{-2} \text{ m}^3$?
- A. 186 kPa
 - B. 196 kPa
 - C. 106 kPa
 - D. 201 kPa
16. Constructive interference of sound waves occurs
- A. whenever there is an echo.
 - B. when two waves arrive at the same point in phase with each other.
 - C. when two waves arrive at the same point out of phase with each other.
 - D. whenever sound waves are refracted by air layers of different temperatures.
17. The entropy of a thermodynamic system increases, when the system is made to convert
- A. heat into work at constant temperature.
 - B. heat into work in a cyclic operation.
 - C. work into heat in a cyclic operation.
 - D. work into heat at a constant temperature.
18. Radiation is heat transfer by
- A. molecular and electronic collisions.
 - B. electromagnetic waves.
 - C. bulk fluid motions.
 - D. atmospheric currents.

19. _____ enables temperature to be defined as that property of a body which decides whether or not it is in thermal equilibrium with another body.
- A. Law of conservation of Energy
 - B. Law of conservation of momentum
 - C. Newton's law of cooling
 - D. Zeroth law
20. The thermometer that depends on the electromotive force change with temperature of two metals joined together is
- A. Constant-volume gas.
 - B. Resistance.
 - C. Thermoelectric.
 - D. Mercury-in-glass.
21. A JUPEB student stands 100cm from a mirror to look at his appearance before going to school. What is his image distance to half his initial position?
- A. 150 cm
 - B. 100 cm
 - C. 50 cm
 - D. 175 cm
22. Find the pressure of two moles of an ideal gas at a temperature of 27°C and volume 10^{-2}m^3 .
- A. $4.99 \times 10^5 \text{ N/m}^2$
 - B. $9.80 \times 10^3 \text{ N/m}^2$
 - C. $4.98 \times 10^3 \text{ N/m}^2$
 - D. $9.80 \times 10^5 \text{ N/m}^2$
23. A near-sighted student has a near point of 0.1m and a focal length of 5.0cm. What is the student's far point?
- A. 0.200m
 - B. 8.000m
 - C. 0.125m
 - D. 2.100m
24. The production of pure spectrum could easily be achieved using a
- A. triangular prism only.
 - B. triangular prism with two concave lenses.

- C. triangular prism with two convex lenses.
- D. glass prism with a pin.

25. The plane of a conducting loop is oriented parallel to the x - y plane. A magnetic field is directed in the z -direction. Which one of the following actions will not change the magnetic flux through the loop?

- A. Decrease the area of the loop.
- B. Increase the strength of the magnetic field.
- C. Rotate the loop about an axis that is directed in the y direction and that passes through the centre of the loop.
- D. Rotate the loop about an axis that is directed in the z direction and that passes through the centre of the loop.

26. The attractive force exerted between two charges of equal magnitude is 4.0×10^{-4} N. If the magnitude of each charge is $2.0 \mu\text{C}$, how far apart are the charges?

- A. 0.95m
- B. 4.00m
- C. 9.50m
- D. 95.00m

27. A coil of wire with N turns and area A is placed into a magnetic field of magnitude B . The angle of the normal to the plane of the coil is at an angle ϕ with respect to the magnetic field. According to Faraday's law, which of the following changes will produce an emf in the coil?

- I. B is decreased
- II. A is increased
- III. ϕ is decreased

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

31. What is the internal energy of 1.0 mol of an ideal monatomic gas at 273 K?

- A. $3.4 \times 10^{-3}\text{J}$
- B. $3.4 \times 10^3\text{J}$
- C. $3.4 \times 10^2\text{J}$

D. $3.4 \times 10^{-2} \text{J}$

29. The ratio of electrostatic force F_E to gravitational force F_G between two protons each of charge e and mass m , at a distance d is

A. $\frac{e^2}{Gm^2}$

B. $\frac{e}{4\pi\epsilon}$

C. $\frac{Gm^2}{4\pi\epsilon_0 e^2}$

D. $\frac{e^2}{4\pi\epsilon_0 Gm^2}$

30. A circuit has a resistance of $200 \, \Omega$. The resistance of the circuit can be reduced to $120 \, \Omega$ by adding which of the following to the circuit?

- A. $80 \, \Omega$ resistor in series.
- B. $150 \, \Omega$ resistor in parallel.
- C. $240 \, \Omega$ resistor in series.
- D. $300 \, \Omega$ resistor in parallel.

31. The major function of a dielectric in a capacitor is to

- A. increase the capacitance of the capacitor.
- B. increase the charge of the capacitor.
- C. decrease the capacitance of the capacitor.
- D. decrease the charge of the capacitor.

32. If an ebonite rod is rubbed with fur, the rod and fur will respectively be

- A. positively charged and negatively charged.
- B. negatively charged and positively charged.
- C. positively charged and positively charged.
- D. negatively charged and negatively charged.

33. Two straight conductor wires of length 4 m , carries current of 1 A each. What is the force on the wire, if the wires are 50 mm apart?

- A. $1.6 \times 10^4 \text{ N}$
- B. $1.6 \times 10^{-5} \text{ N}$

- C. $1.6 \times 10^{-4} \text{ N}$
D. $1.6 \times 10^5 \text{ N}$
34. A current of 0.5A flows through a resistor when connected to a 40V battery. How much energy is dissipated in 2 minutes?
A. 1200J
B. 1500J
C. 2400J
D. 96000J
35. Determine the inductive reactance when a 30.0 mH inductor with a negligible resistance is connected to a $1.30 \times 10^3 \text{ Hz}$ oscillator.
A. 39.0 ohms
B. 122.5 ohms
C. 245.0 ohms
D. 39000.0 ohms
36. The estimated biological effect of absorbed ionizing radiation energy is measured in which of the following units?
A. Becquerel
B. Gray
C. Sieverts
D. Joule.
37. The velocity of electrons emitted from the surface of a metal of work function 4.92eV when irradiated is $2.084 \times 10^7 \text{ m/s}$. Determine the wavelength of the radiation.
A. 0.8nm
B. 1.0nm
C. 1.1nm
D. 1.2nm.
38. Which of the following statements is true regarding a radioactive isotope ${}^A_Z X$ that decays by emitting a gamma ray?
A. The resulting isotope has a different Z value.
B. The resulting isotope has the same A value and the same Z value.
C. The resulting isotope has a different A value.

D. Both A and Z are different.

39. An electron in the $n = 5$ energy level of hydrogen undergoes a transition to the $n = 3$ energy level. Determine the wavelength of the photon the atom emits in this process.

A. 1.28×10^{-6} m

B. 2.37×10^{-6} m

C. 4.22×10^{-7} m

D. 3.04×10^{-6} m

40. (I) attractive in nature.

(II) electrical in nature.

(III) extremely short range.

(IV) strongest forces in nature.

Which of the above phrases are true regarding forces between a proton and a neutron inside the nucleus?

A. (I), (II) and (IV).

B. (II) and (III).

C. (I), (III) and (IV).

D. (III) and (IV).

41. The ionization energy for a hydrogen atom in ground state is 13.6 eV. A photon of energy 4.53 eV strikes a hydrogen atom in ground state. The hydrogen atom will

A. not be excited to a higher energy level.

B. be excited to the first excited state.

C. be excited to the third excited state.

D. be ionized.

42. (I) The frequency of incident radiation.

(II) The intensity of incident radiation.

(III) The work function of the metal.

On which of the above parameters does the maximum energy of photoelectrons depend in photoelectricity?

A. (I) and (II) only.

B. (I) and (III) only.

C. (II) and (III) only.

D. (I), (II) and (III).

43. What is the equivalent of 1.007277amu in MeV?
- A. 1.60×10^{-19}
 - B. 6.02×10^{23}
 - C. 931.48
 - D. 937.77
44. The maximum kinetic energy of the photoelectrons emitted from a metal surface is 0.34eV. If the work function of the metal is 1.83eV, find the stopping potential.
- A. 2.17V
 - B. 1.49V
 - C. 1.09V
 - D. 0.34V
45. I. α -particles
II. β -particles
III. X-rays
IV. γ -rays
- Natural radioactivity consists of which of the above emissions?
- A. I and III only.
 - B. I, II and III only.
 - C. I and II only.
 - D. I, II and IV only.
46. Microwave is an example of electromagnetic wave while radio wave is an example of
- A. sound wave.
 - B. non-periodic wave.
 - C. longitudinal wave.
 - D. electromagnetic wave.
47. What occurs in curved mirrors when all the reflected rays do not pass through a single focus?
- A. Lateral inversion
 - B. Rectilinear Propagation
 - C. Spherical aberration
 - D. Diffused reflection

48. A body of mass 5 kg moving on a level frictionless surface with a velocity of 2 m/s collides with another body of mass 3 kg moving with the same velocity in opposite direction. If the collision is completely inelastic, find the common velocity.
- A. 5.0 m/s
 - B. 0.5 m/s
 - C. 0.05 m/s
 - D. 2.0 m/s
49. A solid of weight 0.60 N is totally immersed in oil and water respectively. If the upthrust in oil is 0.21 N and the relative density of oil is 0.875, determine the upthrust experienced by the solid in water.
- A. 0.24 N
 - B. 24 N
 - C. 240 N
 - D. 0.81 N
50. A body of mass 5 kg is executing a simple harmonic motion with amplitude of 20 mm. If it has a period of oscillation of 1.57 s, what is its maximum velocity?
- A. 0.32 m/s
 - B. 0.08 m/s
 - C. 4.0 m/s
 - D. 1.25 m/s

SECTION B: PHYSICS ESSAYS QUESTIONS

Answer FOUR Questions; One from each Course.

PHY 001: MECHANICS AND PROPERTIES OF MATTER

1. (a) i. Define the terms: work, energy and power.
ii. Calculate the power of a pump which lifts 100kg of water through a vertical distance of 15 meters in 3 seconds. [5½ marks]

- (b) i. Explain the term 'Coefficient of restitution'.
ii. A ball is dropped from a height h above the tile floor and rebounds to a height of $0.65h$. Find the coefficient of restitution between the ball and the floor.

[4½ marks]

[Total = 10 marks]

2. (a) Describe each of the following:

- i. a perfectly elastic collision.
ii. a perfectly inelastic collision.

[2 marks]

- (b) A cricket bat strikes a ball of mass 0.6kg travelling towards it. The ball initially hits the bat at a speed of 25m/s and returning along the same path with the same speed. The time of impact is 0.0030s.

- i. Determine the change in momentum of the cricket ball.
ii. Calculate the force exerted by the bat on the cricket ball.
iii. State whether the collision is elastic or inelastic and give reasons. [5 marks]

- (c) A stone projected horizontally with a velocity of 15ms^{-1} from the top of building lands at a horizontal distance of 60m from the building. Calculate the height of the building.

[3 marks]

[Total = 10 marks]

PHY 002: HEAT, WAVES AND OPTICS

3. (a) Define the following and give an example each:

- i. Transverse wave.
ii. Longitudinal waves.

[3 marks]

- (b) State **FOUR** characteristics of a wave. [2 marks]

- (c) i. A carnot engine operates between two reservoirs at 450 K and 600 K. What is the coefficient of performance of the engine?

- ii. A carnot engine whose low-temperature reservoir is at 200 K has an efficiency of 45%. By how much must the temperature of the high-temperature reservoir be raised if

the efficiency is to be increased to 60%, the temperature of the low-temperature reservoir being unchanged? [5 marks]

[Total = 10 marks]

4. (a) i. State any **FOUR** postulates of kinetic theory of gas.
ii. What is the average translational energy of an oxygen molecule for such a particle in air at 350K? [5 marks]
- (b) A plane-progressive wave is represented by the equation $y = 3.0 \sin(300\pi t - 0.3\pi x)$. If all the variables are in S.I. units, Calculate the:
i. amplitude;
ii. frequency;
iii. wavelength; and
iv. speed of the wave. [5 marks]

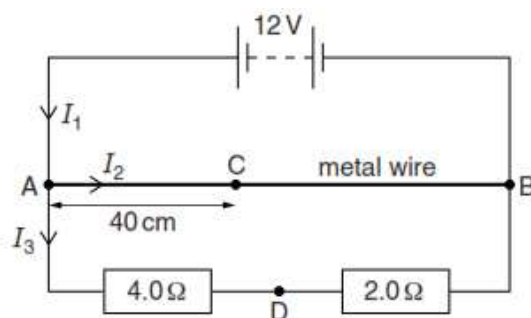
[Total = 10 marks]

PHY 003: ELECTRICITY AND MAGNETISM

5. (a) i. State Faraday's law of electromagnetic induction.
ii. A RLC circuit is used in a radio to tune into the radio FM station broadcasting at 94.4 MHz. The resistance in the circuit is 12Ω and the inductance is $5.3 \mu\text{H}$. What capacitance should be used? [3½ marks]
- (b) A step-up transformer has 240V input which is transformed to 150kV output. The primary coil has 70 loops and draws a current of 20A when in use.
i. What is the number of loops in the secondary coil?
ii. Calculate the current output. [4 marks]
- (c) How much energy is stored in a 0.008 mH inductor when a 30.0 A current flows through it? [2½ marks]
- [Total = 10 marks]

6. (a) Write an expression each for capacitive reactance and inductive reactance. [2 marks]

- (b) The Figure below shows a 12V power supply with negligible internal resistance connected to a uniform metal wire AB. The wire has length 1.00m and resistance 10Ω . Two resistors of resistance 4.0Ω and 2.0Ω are connected in series across the wire.



Currents I_1 , I_2 and I_3 in the circuit are as shown in the circuit above.

- State a relationship between I_1 , I_2 and I_3 .
- Calculate I_1 .
- Calculate the ratio of power in the metal wire to the power in the series resistor.
- Calculate the potential difference (p.d.) between the points C and D, as shown in the Figure. The distance AC is 40 cm and D is the point between the two series resistors.

[8 marks]

[Total = 10 marks]

PHY 004: MODERN PHYSICS

- Briefly explain the term “LASER” and state **FOUR** of its applications. [3 marks]
 - Estimate the change in energy ΔE of an electron that jumps from the L shell to the K shell of Molybdenum ($Z = 42$). [2½ marks]
 - A beam of neutrons moving with a speed of 1450 m/s is diffracted from a crystal of salt which has an interplanar spacing of 0.282 nm.
 - Compute the De Broglie’s wavelength of the neutrons.
 - Calculate the angle of the first interference minimum. [4½ marks]

[Total = 10 marks]

- What do you understand by the term “binding energy”?
 - Calculate the binding energy per nucleon of the Helium nucleus ${}^4_2\text{He}$.
(mass of proton = 1.0073u, mass of neutron = 1.0073u, mass of helium nucleus = 4.0015u) [4 marks]
 - What potential difference is required between the anode and cathode of a vacuum tube if the electrons are to reach a velocity of $5.0 \times 10^6 \text{ ms}^{-1}$?
 - If the electron current in (b)i is 10.0 mA, what is the power dissipated at the anode? ($e/m = 1.76 \times 10^{11} \text{ C kg}^{-1}$) [4 marks]
 - Draw the circuit symbol of a p-n-p transistor.
 - Explain the term full-wave rectification. [2 marks]

[Total = 10 marks]