Reg. No.										

INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

I SEMESTER B.S. DEGREE EXAMINATION – JUNE 2016

SUBJECT: PHYSICS - I (PH 111)

(COMMON TO ALL BRANCHES)

(NEW SCHEME)

THURSDAY, 9th JUNE, 2016

Time: 3 Hours **Max. Marks: 100**

- ✓ **Answer ANY FIVE FULL Questions.**
- ✓ **Any missing data may be suitably assumed**

PHYSICAL CONSTANTS

Elementary charge e = 1.602×10^{-19}C

Electron constant $m_e = 9.11 \times 10^{-31}$kg

Boltzmann constant k = 1.38×10^{-23} J/K

Planck's constant h = 6.626×10^{-34} Js

Speed of light in vacuum c = 3×10^{8} m/s

Stefan – Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4

Wein's displacement constant b = 2.89×10^{-3} mK

Avogadro number NA = 6.023×10^{23}

1A. Explain the following: i) Phase change on reflection ii) Optical path length

1B. With necessary diagram, obtain an expression for the fringe-width of double slit interference pattern.

1C. (i) Find the sum of the following quantities using phasors:

$y_1 = 8 \sin(\omega t)$

$y_2 = 6 \sin(\omega t + 20°)$

(ii) The stopping potential for photoelectrons released from a metal is 1.48 V larger compared to that in another metal. If the threshold frequency for the first metal is 40% smaller than for the second metal, determine the work function for each metal.

[(2+2)+8+(4+4)=20 MARKS]

2A. Explain the following terms with reference to lasers:

(i) Spontaneous emission

(ii) Stimulated emission

2B. Obtain an expression for the half angular width of any principal maximum in diffraction pattern due to multiple slits.

2C. (i) The double slit arrangement is illuminated by light of wavelength 546 nm. The slits are 0.12 mm apart and the screen on which interference pattern appears is 55 cm away. What is the angular position of first minima and tenth maxima? What is the separation between two adjacent maxima?

(ii) A 0.00160 nm photon scatters from a free electron. For what photon scattering angle does the recoiling electron have kinetic energy equal to the energy of the scattered photon?

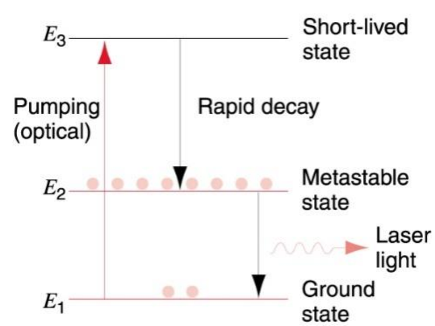
[(2+2)+8+(4+4)=20 MARKS]

3A. (i) Explain Planck's radiation law.

(ii) Write the assumptions made in Planck's hypothesis of blackbody radiation.

3B. Explain construction and working of He-Ne laser with necessary diagrams.

3C. (i) A three level laser of the type shown in figure, emits laser light at a wavelength 550 nm, near the centre of the visible band. If the optical mechanism is shut off, what will be the ratio of the population of the upper level E2 to that of the lower level E1 at 300 K ? At what temperature for the condition of (a) would the ratio of populations be half ?



(ii) A step index optical fibre 63.5 μm in core-diameter has a core of refractive index 1.53 and a cladding of index 1.39. Determine (a) the numerical aperture for the fibre, (b) the critical angle for core-cladding interface, (c) the acceptance cone half-angle (the maximum entrance angle) (d) the number of reflections in 1.0 m length of the fibre for a ray at the maximum entrance angle.

[(2+2)+8+(4+4)=20 MARKS]

4A. Sketch schematically the following graphs with reference to the photoelectric effect:

(i) Photoelectric current vs applied voltage

(ii) Kinetic energy of most-energetic electron vs frequency of incident light.

4B. Explain wave packet, group speed and phase speed. Show that the group speed of a wave packet is equal to the particle speed.

4C. (i) A 0.50 kg baseball is confined between two rigid walls of a stadium that can be modeled as a "box" of length 100 m. Calculate the minimum speed of the baseball. If the baseball is moving with a speed of 150 m/s, what is the quantum number of the state in which the baseball will be?

(ii) Electrons are incident on a pair of narrow slits 0.060 μm apart. The 'bright bands' in the interference pattern are separated by 0.40 mm on a 'screen' 20.0 cm from the slits. Determine the potential difference through which the electrons were accelerated to give this pattern.

[(2+2)+8+(4+4)=20 MARKS]

5A. (i) Explain the interference in wedge-shaped thin films.

(ii) What is diffraction grating? Write the grating equation.

5B. Sketch the potential-well diagram of finite height U and length L, obtain the general solution of the Schrödinger equation for a particle of mass m in it.

5C. (i) A 30-eV electron is incident on a square barrier of height 40 eV. What is the probability that the electron will tunnel through the barrier if its width is (a) 1.0 nm? (b) 0.10 nm?

(ii) A diffraction grating has 10^4 rulings uniformly spaced over 25.0mm. It is illuminated at normal incidence by yellow light from sodium vapor lamp which contains two closely spaced lines of wavelengths 589.00nm and 589.59nm. (a) At what angle will the first order maximum occur for the first of these wavelengths? (b) What is the angular separation between the first order maxima of these lines?

[(2+2)+8+(4+4)=20 MARKS]

6A. (i) What is a wave function ? What is its physical interpretation ?

(ii) What are the mathematical features of a wave function?

6B. The wave function for H-atom in ground state is $\psi_{1S}(r) = \frac{1}{\sqrt{\pi a_o^3}} \exp\left(-\frac{r}{a_o}\right)$.

Obtain an expression for the radial probability density of H-atom in ground state. Sketch schematically the plot of this vs. radial distance.

6C. (i) A converging lens 32mm in diameter has a focal length f of 24 cm. (a) What angular separation must two distant point objects have to satisfy Rayleigh's criterion? Assume that l = 550nm. (b) How far apart are the centers of the diffraction patterns in the focal plane of the lens?

(ii) A blackbody at 7500 K consists of an opening of diameter 0.050 mm, looking into an oven. Find the number of photons per second escaping the hole and having wavelengths between 500 nm and 501 nm.

[(2+2)+8+(4+4)=20 MARKS]

7A. (i) Why the electrical conductivity of an intrinsic semiconductor increases with increasing temperature?

(ii) Indicate the position of (a) donor levels (b) acceptor levels, in the energy band diagram of a semiconductor.

7B. Assuming the Fermi-Dirac distribution function , obtain an expression for the density of free-electrons in a metal with Fermi energy E_F, at zero K and, hence obtain expression for Fermi energy E_F in a metal at zero K. [Given: density-of-states function $g(E)\,dE = \frac{8\sqrt{2}\,\pi\, m^{3/2}}{h^3} E^{1/2}\, dE$]

7C. (i) Sodium is a monovalent metal having a density of 971 kg/m^3 and a molar mass of 0.023 kg/mol. Use this information to calculate (a) the density of charge carriers and (b) the Fermi energy.

(ii) (a) Using the simple model of a particle in a box to represent an atom, estimate the energy (in eV) required to raise an atom from the state n =1 to the state n =2. Assume the atom has a radius of 0.10 nm and that the moving electron carries the energy that has been added to the atom. (b) Atoms may be excited to higher energy states by absorbing photon energy. Calculate the wavelength of the photon that would cause the transition from the state n =1 to the state n =2.

[(2+2)+8+(4+4)=20 MARKS]

8A (i) What are superconductors? Draw a representative graph of Resistance Vs Temperature for a superconductor.

(ii) What is Meissner effect?

8B Explain the formation of energy bands in solids with necessary diagrams. Hence distinguish metals, semiconductors and insulators.

8C (i) A He-Ne laser emits light at a wavelength of 632.8 nm and has an output power of 2.3 mW. How many photons are emitted each minute by this laser when operating ?

(ii) A free electron has a wave function $\psi(x) = A\exp[i(5.0\times 10^{10})x]$ where x is in meters. Find (a) its de Broglie wavelength, (b) its momentum, and (c) its kinetic energy in electron volts.

[(2+2)+8+(4+4)=20 MARKS]