Reg.No.									

INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

I SEMESTER B.S. DEGREE EXAMINATION – NOV. / DEC. 2016

SUBJECT: PHYSICS - I (PH 111)
(NEW SCHEME)
(BRANCH: COMMEN TO ALL)
Saturday, 10 December 2016

Duration: 3 Hrs. **Max. Marks: 100**

Physical Constants:

Elementary charge:	1.6×10^{-19} C
Mass of electron:	9.1×10^{-31} kg
Boltzmann constant:	1.38×10^{-23} J/K
Planck's constant:	6.625×10^{-34} J.s
Stefan-Boltzmann constant:	5.67×10^{-8} W/m^{2}K^4
Speed of light in vacuum:	3.0×10^{8} m/s

- ✓ **Answer Any FIVE FULL questions. Each FULL question carries 20 marks**
- ✓ **Answer all the sub questions of a main question in a continuous sequence.**
- ✓ **Write specific and precise answers. Any missing data may suitably be assumed.**
- ✓ **Write question number on the left side of the margin. Draw neat sketches wherever necessary.**

1A. i) Mention the conditions for observing steady interference pattern of light waves and any two conditions for good contrast of the interference pattern.

ii) Draw a schematic plot of the intensity of light in a double-slit interference against phase-difference.

1B. i) Obtain an expression for the half angular width of any principal maximum in diffraction pattern due to multiple slits.

ii) Distinguish between Fresnel and Fraunhofer Diffraction.

1C. i) The radius of Sun is 6.96×10^{8} m, and its total power output s 3.77×10^{26} W.

(a) Assuming that the Sun's surface emits as a black body, calculate its surface temperature.

(b) Using the result, find λ_{max} for the Sun.

ii) A certain grating has 10^{4} slits with a spacing of 2100 nm. It is illuminated with yellow sodium light (λ = 589 nm). Find (a) angular position of all principal maxima observed and (b) angular width of the largest order maximum. **[4+8+8]**

2A. Explain construction and operation of He-Ne laser with necessary diagrams.

2B. i) Explain Compton effect. ii) Derive the Compton shift equation.

2C i) 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?

ii) A ruby laser emits light at wavelength 694.4nm. If a laser pulse is emitted for 12ps and the energy release per pulse is 150mJ. What is the length of the pulse and how many photons are there in each pulse? **[4+8+8]**

3A. i) Explain a wave packet and represent it schematically. ii) Show that the group speed of a wave packet is equal to the particle speed.

3B. Sketch the potential-well diagram of finite height U and length L for a particle of mass 'm' in it. Write Schrodinger equation for three regions. Write the corresponding wave functions and boundary conditions.

3C. i) A free electron has a wave function Ψ = A exp [i (5.00 x 1010) x] where x is in meters. Find (a) its de Broglie wavelength (b) its momentum and (c) its kinetic energy in electron volts.

ii) A thin film of acetone (index of refraction = 1.25) is coating a thick glass plate (index of refraction = 1.50). Plane light waves of variable wavelengths are incident normal to the film. When one views the reflected wave, it is noted that complete destructive interference occurs at 600 nm and constructive interference at 700 nm. Calculate the thickness d of the acetone film? **[4+8+8]**

4A. Obtain an expression for numerical aperture of an optical fiber in terms of refractive index of core and cladding.

4B. Based on the quantized allowed states of a particle in a three dimensional infinite potential well (box), derive the density-of-states function.

4C. i) Sodium is a monovalent metal having a density of 971 kg/m3 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) In a double-slit experiment, the distance of the screen from the slits is 52 cm, the wavelength is 480 nm, slit separation is 0.12 mm and the slit width is 0.025 mm. (a) What is the spacing between adjacent fringes? (b) What is the distance from the central maximum to the first minimum of the fringe envelope? (c) How many fringes are there in the central peak of the diffraction envelope? **[4+8+8]**

5A. Explain the BCS theory of superconductivity in metals.

5B. Derive an expression for intensity of diffraction pattern in the case of single-slit, using phasor diagram. Sketch the diffraction pattern due to a single slit.

5C. i) Molybdenum has a work function of 4.2eV. (a) Find the cut off wavelength and cut off frequency for the photoelectric effect. (b) What is the stopping potential if the incident light has wavelength of 180 nm?

ii) A step index optical fiber 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 fiber, (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 fiber for a ray at the maximum entrance angle. **[4+8+8]**

6A. The wave function for H-atom in ground state is $\psi_{1s}(r) = \frac{1}{\sqrt{\pi a_0^3}} e^{-\frac{r}{a_0}}$

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

6B. Explain photoelectric effect. What are the observations in the experiment on photoelectric effect? Sketch schematically the following graphs with reference to the photoelectric effect: (a) photoelectric current vs applied voltage (b) kinetic energy of most-energetic electron vs frequency of incident light.

6C. i) A proton is confined to move in a one-dimensional box of length 0.20 nm. (a) Find the lowest possible energy of the proton. (b) What is the lowest possible energy for an electron confined to the same box? (c) Account for the great difference in results for (a) and (b).

ii) 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. a) What is the angular position of (1) first minima and (2) tenth maxima? b) What is the separation between two adjacent maxima? **[4+8+8]**

7A. What are the classical predictions about the photoelectric effect?

7B. Solve the Schrodinger equation for a particle of mass m in a one-dimensional infinite potential well (box) of length L and obtain the expressions for wave functions of the particle.

7C. i) Consider a system of electrons confined to a three-dimensional box. (a) Calculate the ratio of the number of allowed energy levels at 8.50 eV to the number at 7.00 eV. (b) Copper has a Fermi energy of 7.0 eV at 300 K. Calculate the ratio of the number of occupied levels at an energy of 8.50 eV to the number at Fermi energy.

ii) An electron with kinetic energy 5.0 eV is incident on a barrier with thickness 0.20 nm and height 10.0 eV. What is the probability that the electron (a) will tunnel through the barrier? (b) will be reflected? **[4+8+8]**

8A. Discuss qualitatively the diffraction due to multiple slits (example: 5 slits).

8B. Obtain an expression for the intensity of light in double-slit interference using phasor diagram. Write the condition for maxima and minima.

8C. i) Monochromatic light with wavelength 538 nm falls on a slit with width 25.2 μm. The distance from the slit to a screen is 3.48 m. consider a point on the screen 1.13 cm from the central maximum. (a) Calculate θ (b) Calculate α (c) Calculate the ratio of the intensity at this point to the intensity at the central maximum.

ii) The energy gap for silicon at 300 K is 1.14 eV. (a) Find the lowest frequency-photon that can promote an electron from the valence band to the conduction band. (b) What is the wavelength of this photon? **[4+8+8]**