Kafr Elshiekh University
Faculty of Engineering
Department of
Physical and Mathematical Engineering
First Year

19- 01- 2020
3 hours
90 Marks
Final exam: 3 pages

Engineering physics (2)

Answer the following questions:

Question(1) : (ILOs: a1) ***(15 Marks)***

(a) An object of mass 'm' is hung from a spring and set into oscillation. The period of the oscillation is measured and recorded as T.

The object is removed and replaced by a new object of mass '3m', when the new object is set into oscillation, what would be the period of the motion?

(b)A spring is hanging without any object attached to it, its length is 500mm. An object of mass 200g is attached to the end of the spring. The length of the spring is now 850mm

- What is the spring force constant?
- What is the natural frequency of the oscillation? ($g=9.8\ m/s^2$)

Question(2) : (ILOs: b1) ***(15 Marks)***

(a)A transverse wave is traveling on a taut wire has a frequency of 500 Hz. It travels with a speed of 200m/s.

- What is the wave number?
- The mass per unit length of this wire is 4.1 g/m. Find the tension in the wire.

(b) What is the speed of sound in air (M=29g/mol and $\gamma=1.4$) on a day when the temperature is $25^{o}C$? (R=8.314 J/kg.K)?

Question(3) : (ILOs: a2) ***(15 Marks)***

(a)What length of open pipe will produce a frequency of 1200 Hz as it first over tone on a day when the speed of sound is 345m/s?

(b) Red light falls normally on a diffraction grating ruled 4000 lines/cm, and the second-order image is diffracted 34^{o} from the normal. Calculate the wavelength of the light.

(c) Explain constructive interference and destructive interference with diagrams.

Question(4) : (ILOs: a2) ***(15 Marks)***

(a) Choose the best answer:
1- Application of a forward bias to a p-n junction:
A. narrows the depletion zone
B. increases the electric field in the depletion zone
C. increases the potential difference across the depletion zone
D. increases the number of donors on the n side
E. decreases the number of donors on the n side
2- A given doped semiconductor can be identified as p or n type by:
A. measuring its electrical conductivity B. measuring its magnetic susceptibility
C. measuring its coefficient of resistivity D. measuring its heat capacity
E. performing a Hall effect experiment
3- For a pure semiconductor the Fermi level is:
A. in the conduction band B. well above the conduction band
C. in the valence band D. well below the valence band
E. near the center of the gap between the valence and conduction bands
4- At room temperature kT is about 0.0259 eV. The probability that a state 0.5 eV below the Fermi level is unoccupied at room temperature is:
A. 1 B. 0.05 C. 0.025 D. 5×10^{-6} E. 4.1×10^{-9}
5-Bohr's quantum condition on electron orbits requires:
(*a*) That the angular momentum of the electron about the hydrogen nucleus equal n ħ.
(*b*) That no more than one electron occupy a given stationary state.
(*c*) That the electrons spiral into the nucleus while radiating electromagnetic waves.
(*d*) That the energies of an electron in a hydrogen atom be equal to nE_0, where E_0 is a constant energy and n is an integer

(b) How To find energy gap of a semiconductor?

(c) Compare between Thomson's model and Rutherford's model.

Question(5) : (ILOs: b2) ***(15 Marks)***

(a) Choose the best answer:
1- A certain metal has 5.3×10^{29} conduction electrons/m3 and an electrical resistivity of $1.9 \times 10^{-9}\ \Omega \cdot$ m. The average time between collisions of electrons with atoms in the metal is:
A. 5.6×10^{-33} s B. 1.3×10^{-31} s C. 9.9×10^{-22} s D. 4.6×10^{-15} s E. 3.5×10^{-14} s
2- A particle is confined by finite potential energy walls to a one-dimensional trap from x = 0 to x = L. Its wave function in the region x > L has the form:
A. $\psi(x) = A\sin(kx)$ B. $\psi(x) = Ae^{kx}$ C. $\psi(x) = Ae^{-kx}$ D. $\psi(x) = Ae^{ikx}$ E. $\psi(x) = 0$
3-In order to tunnel through a potential barrier a particle must:
A. have energy greater than the barrier height B. have spin C. be massive
D. have a wavelength longer than the barrier width E. none of the above

4- A free electron has a momentum of 5 × 10–24 kg · m/s. The wavelength of its wave function is:
A. 1.3×10^{-8} m B. 1.3×10^{-10} m C. 2.1×10^{-11} m D. 2.1×10^{-13} m E. none of these

5- The energy gap (in eV) between the valence and conduction bands of an insulator is of the order of:
A. 10^{-19} B. 0.001 C. 0.1 D. 10 E. 1000

(b) 1- Sketch the one-dimensional "top hat" potential (1) V = 0 for x < 0; (2) V = W = constant for $0 \le x \le L$; (3) V = 0 for x > L.

2- Consider particles, of mass m and energy E < W incident on this potential barrier from the left (x < 0). Including possible reflections from the barrier boundaries, write down general expressions for the wave functions in these regions and the form the time-independent Schrodinger equation takes in each region. What ratio of wave function amplitudes is needed to determine the transmission coefficient?

3- Write down the boundary conditions for Ψ and dΨ/dx at x = 0 and x = L.

4- A full algebraic solution for these boundary conditions is time consuming. In the approximation for a tall or wide barrier, the transmission coefficient T is given by

$$T = 16\left(\frac{E}{W}\right)\left(1-\frac{E}{W}\right)e^{-2\alpha L}$$

where

$$\alpha^2 = 2m\left(\frac{W-E}{\hbar^2}\right)$$

Determine T for electrons of energy E = 2 eV, striking a potential of value W = 5 eV and width L = 0.3nm.

5- Describe two examples where quantum mechanical tunneling is observed.

(c) Discuss the different distribution functions.

Question(6) : (ILOs: c2) ***(15 Marks)***

(a) A semiconductor diode laser has a peak emission wavelength of 1.55 μm. Find its band gap in eV.

(b) The critical field for niobium is 1×10^5 amp/m at 8 K and 2×10^5 amp/m at absolute zero. Find the transition temperature of the element.

(c) Discuss the photo-diode and LED.

(d) State three of nanometallic particles' properties.

Useful data : $q_e = 1.6022 \times 10^{-19}$ C, $c = 3 \times 10^8$ m/s, $m_e = 9.1 \times 10^{-31}$ kg, $h = 6.63 \times 10^{-34}$ J.s, $K_B = 1.38 \times 10^{-23}$ J/K, $N_A = 6.022 \times 10^{23}$/mol

Assume any missing data

Best Wishes

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