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PU CET (PG) Physics Sample Paper 2027

Panjab University PU-CET (P.G.) · M.Sc. Physics / Physics (Electronics) / Medical Physics · Practice Paper 1

Questions	Marks	Time	Negative marking
75 MCQs	**75 (1 each)**	**90 minutes**	**1/4 mark per wrong answer**

Part	Section	Questions	Q. No.
Physics	Mechanics and Special Relativity	10	1 to 10
Physics	Electricity and Magnetism	10	11 to 20
Physics	Waves and Optics	8	21 to 28
Physics	Thermal and Statistical Physics	9	29 to 37
Physics	Quantum Mechanics and Atomic Physics	10	38 to 47
Physics	Mathematical Physics	7	48 to 54
Physics	Solid State Physics	7	55 to 61
Physics	Nuclear and Particle Physics	7	62 to 68
Physics	Electronics	7	69 to 75

Instructions

1. This paper has 75 multiple-choice questions on B.Sc. Physics (Panjab University syllabus, all three years). Each question has four options (A, B, C, D); choose the one correct answer.
2. Each correct answer gets 1 mark and 1/4 mark is deducted for each wrong answer. An unattempted question gets no mark.
3. Time allowed is 90 minutes. Calculators are not allowed; answers are marked on an OMR sheet in the actual test.
4. The questions are grouped by topic here for practice. The real PU-CET (P.G.) Physics booklet numbers them 1 to 75 without section headings.
5. Useful values: $h = 6.6 \times 10^{-34}$ J s, $c = 3 \times 10^{8}$ m/s, $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg, $1\ u = 931.5$ MeV/c^2.
6. The answer key and solutions are at the end. Check them only after you finish.

This is an AglaSem practice paper written on the official PU-CET (P.G.) 2026 scheme for M.Sc. Physics (75 MCQs, 90 minutes, 1/4 negative marking). It is not an official Panjab University paper, and its questions are not taken from any PU paper. The same entrance test covers M.Sc. Physics, Physics (Specialisation in Electronics) and the 2-year M.Sc. Medical Physics.

Physics

Mechanics and Special Relativity

1. The position of a particle moving along the x-axis is $x(t) = t^3 - 6t^2 + 9t$, where x is in metres and t in seconds. The particle is momentarily at rest at:

(A) t = 0 s and t = 3 s
(B) t = 1 s and t = 2 s
(C) t = 1 s and t = 3 s
(D) t = 2 s only

2. A projectile is fired so that its horizontal range is four times its maximum height. The angle of projection is:

(A) 60°
(B) $\tan^{-1} 4$
(C) 45°
(D) 30°

3. The moment of inertia of a uniform solid sphere of mass M and radius R about a diameter is:

(A) $(1/2)MR^2$ (B) $(7/5)MR^2$

(C) $(2/3)MR^2$ (D) $(2/5)MR^2$

4. A skater spinning freely pulls in her arms so that her moment of inertia becomes one-third of its initial value. Her rotational kinetic energy:

(A) increases nine times (B) falls to one-third

(C) stays the same (D) increases three times

5. The escape velocity from the surface of a planet is v_e. The speed of a satellite in a circular orbit just above its surface is:

(A) $\sqrt{2}\, v_e$ (B) $v_e/2$

(C) $v_e/\sqrt{2}$ (D) $2v_e$

6. If the radius of a satellite's circular orbit is made four times, its period of revolution becomes:

(A) 8 times (B) 16 times

(C) 4 times (D) 2 times

7. The number of degrees of freedom of a rigid body free to move in three-dimensional space is:

(A) 9 (B) 6

(C) 3 (D) 5

8. A rod of proper length L moves along its own length with speed 0.8c. Its length measured in the laboratory is:

(A) 0.6L (B) 1.67L

(C) L (D) 0.8L

9. A particle with proper lifetime τ moves with speed 0.8c in the laboratory. Its lifetime measured in the laboratory is:

(A) $3\tau/5$ (B) $5\tau/3$

(C) $5\tau/4$ (D) $4\tau/5$

10. The total energy of a particle is twice its rest energy. Its speed is:

(A) $(\sqrt{3}/2)c$ (B) $c/\sqrt{2}$

(C) $c/2$ (D) $(3/4)c$

Electricity and Magnetism

11. The electric field inside a uniformly charged thin spherical shell is:

(A) uniform but non-zero (B) proportional to $1/r^2$

(C) proportional to r (D) zero at every point

12. The electric field near an infinite plane sheet carrying uniform surface charge density σ is:

(A) $\sigma/2\varepsilon_0$ (B) σ/ε_0

(C) $2\sigma/\varepsilon_0$ (D) $\sigma/4\pi\varepsilon_0$

13. A parallel-plate capacitor storing energy U is disconnected from the battery. A dielectric of constant K is then inserted to fill the gap. The stored energy:

(A) becomes KU (B) becomes K^2U

(C) stays U (D) becomes U/K

14. The magnetic field at the centre of a circular loop of radius R carrying current I is:

(A) $\mu_0 I/4\pi R$ (B) $\mu_0 IR/2$

(C) $\mu_0 I/2R$ (D) $\mu_0 I/2\pi R$

15. The magnetic field inside a long solenoid having n turns per unit length and carrying current I is:

(A) $\mu_0 nI$ (B) $\mu_0 nI/2$

(C) zero (D) $\mu_0 I/2$

16. The negative sign in Faraday's law, $\varepsilon = -d\Phi/dt$, is an expression of:

(A) Coulomb's law (B) Gauss's law

(C) Ampère's law (D) Lenz's law

17. The Maxwell equation $\nabla \cdot B = 0$ means that:

(A) magnetic field is always zero

(B) electric charge is conserved

(C) there are no magnetic monopoles

(D) magnetic field lines are straight

18. Maxwell's displacement current density is given by:

(A) $\mu_0\, \partial H/\partial t$ (B) $\partial \rho/\partial t$

(C) σE (D) $\varepsilon_0\, \partial E/\partial t$

19. The Poynting vector $S = E \times H$ represents the:

(A) momentum of a single photon

(B) electromagnetic power per unit area

(C) force on a moving charge

(D) rate of change of the charge density

20. A series LCR circuit has L = 10 mH and C = 1 μF. Its resonant angular frequency is:

(A) 10^4 rad/s (B) 10^5 rad/s

(C) 10^3 rad/s (D) 10^2 rad/s

Waves and Optics

21. In Young's double-slit experiment, λ = 600 nm, the slit separation is 0.3 mm and the screen is 1 m away. The fringe width is:

(A) 0.50 mm (B) 2.0 mm

(C) 20 mm (D) 0.20 mm

22. In Newton's rings seen in reflected light, the diameter of the nth dark ring is proportional to:

(A) n^2 (B) $1/n$

(C) n (D) $\sqrt{n}$

23. Light is incident on glass of refractive index $\sqrt{3}$. The Brewster angle is:

(A) 90° (B) 30°

(C) 60° (D) 45°

24. Unpolarised light of intensity I_0 passes through two polarisers whose transmission axes are at 60° to each other. The emergent intensity is:

(A) $I_0/4$ (B) $I_0/2$

(C) $I_0/8$ (D) $3I_0/8$

25. The resolving power of a plane diffraction grating with N lines, used in the nth order, is:

(A) N/n (B) N

(C) n (D) nN

26. In Fraunhofer diffraction at a single slit of width a, the first minimum occurs where sin θ equals:

(A) 2λ/a (B) λ/2a

(C) λ/a (D) a/λ

27. The speed of a transverse wave on a string of tension T and mass per unit length μ is:

(A) √(μ/T) (B) T/μ

(C) √(T/μ) (D) √(Tμ)

28. In a non-dispersive medium, the group velocity v_g and phase velocity v_p are related as:

(A) $v_g = v_p/2$ (B) $v_g = v_p$

(C) $v_g = c$ (D) $v_g = 2v_p$

Thermal and Statistical Physics

29. A Carnot engine works between reservoirs at 500 K and 300 K. Its efficiency is:

(A) 25% (B) 60%

(C) 40% (D) 67%

30. n moles of an ideal gas expand isothermally and reversibly from volume V to 2V. The change in entropy of the gas is:

(A) zero (B) nR

(C) 2nR ln 2 (D) nR ln 2

31. For a monatomic ideal gas, the ratio of specific heats γ = Cp/Cv is:

(A) 9/7 (B) 5/3

(C) 4/3 (D) 7/5

32. The average translational kinetic energy of a molecule of an ideal gas at absolute temperature T is:

(A) kT (B) (3/2)kT

(C) 3kT (D) (1/2)kT

33. For a gas obeying the Maxwell–Boltzmann distribution, the most probable speed v_{mp}, average speed v_{avg} and rms speed v_{rms} are in the order:

(A) $v_{mp} < v_{avg} < v_{rms}$ (B) $v_{avg} < v_{mp} < v_{rms}$

(C) $v_{rms} < v_{avg} < v_{mp}$ (D) $v_{mp} = v_{avg} = v_{rms}$

34. Particles with half-integral spin obey:

(A) Bose–Einstein statistics (B) Maxwell–Boltzmann statistics

(C) Fermi–Dirac statistics (D) Planck's law only

35. If the absolute temperature of a black body is doubled, the total power it radiates becomes:

(A) 4 times (B) 16 times

(C) 8 times (D) 32 times

36. The Clausius–Clapeyron equation gives:

(A) the slope of a phase-boundary curve

(B) the entropy of an ideal gas at 0 K

(C) the efficiency of a heat engine

(D) the speed distribution of gas molecules

37. According to the third law of thermodynamics, the entropy of a perfect crystal at absolute zero is:

(A) zero (B) −R

(C) infinite (D) R ln 2

Quantum Mechanics and Atomic Physics

38. An electron at rest is accelerated through a potential difference of 100 V. Its de Broglie wavelength is about:

(A) 12.3 Å
(B) 1.23 Å
(C) 0.123 Å
(D) 0.0123 Å

39. Photons of energy 4.0 eV fall on a metal of work function 2.0 eV. The stopping potential is:

(A) 2.0 V
(B) 1.0 V
(C) 6.0 V
(D) 4.0 V

40. A particle is confined in a one-dimensional infinite potential well. If the width of the well is doubled, its ground-state energy:

(A) becomes four times
(B) becomes one-fourth
(C) becomes half
(D) becomes double

41. The commutator $[x, p_x]$ of position and momentum operators equals:

(A) $-i\hbar$
(B) $i\hbar$
(C) $\hbar$
(D) 0

42. The energy separation between adjacent levels of a one-dimensional quantum harmonic oscillator of angular frequency ω is:

(A) $2\hbar\omega$
(B) $\hbar\omega/2$
(C) $3\hbar\omega/2$
(D) $\hbar\omega$

43. The energy of the electron in the $n = 2$ state of a hydrogen atom is:

(A) −1.51 eV
(B) −6.8 eV
(C) −13.6 eV
(D) −3.4 eV

44. The splitting of spectral lines when the source is placed in a magnetic field is called the:

(A) Raman effect
(B) Stark effect
(C) Zeeman effect
(D) Compton effect

45. The maximum number of electrons that can occupy the shell with principal quantum number $n = 3$ is:

(A) 9
(B) 32
(C) 8
(D) 18

46. The wave function $\psi(x) = A\, e^{(-|x|/a)}$, for $-\infty < x < \infty$, is normalised. The value of A is:

(A) $\sqrt{a}$
(B) $\sqrt{(2/a)}$
(C) $1/a$
(D) $1/\sqrt{a}$

47. In Compton scattering by a free electron (rest mass m_0), the maximum change in wavelength of the photon is:

(A) zero
(B) $h/(m_0c)$
(C) $2h/(m_0c)$
(D) $h/(2m_0c)$

Mathematical Physics

48. For any scalar field ϕ with continuous second derivatives, $\nabla \times (\nabla\phi)$ is:

(A) zero
(B) $\nabla^2\phi$
(C) $\nabla\phi$
(D) undefined

49. The divergence of the position vector $\mathbf{r} = x\,\hat{\imath} + y\,\hat{\jmath} + z\,\hat{k}$ is:

(A) r
(B) 3
(C) 0
(D) 1

50. Gauss's divergence theorem states that:

(A) $\oint F \cdot dl = \int (\nabla \times F) \cdot dA$ (B) $\oint F \cdot dA = \int F \, dV$

(C) $\int (\nabla \cdot F) \, dV = \oint F \cdot dA$ (D) $\int (\nabla \times F) \, dV = \oint F \cdot dl$

51. The eigenvalues of the matrix [[2, 1], [1, 2]] are:

(A) 0 and 4 (B) –1 and 3

(C) 1 and 3 (D) 2 and 2

52. The Fourier series of f(x) = x on the interval (–π, π) contains:

(A) sine terms and no cosine terms

(B) both sine and cosine terms

(C) cosine terms and a constant term

(D) a constant term and nothing else

53. The Laplace transform of sin(at) is:

(A) $a/(s^2 - a^2)$ (B) $a/(s^2 + a^2)$

(C) $s/(s^2 + a^2)$ (D) $1/(s - a)$

54. The Legendre polynomial $P_2(x)$ is:

(A) $x^2 - 1$ (B) $(3x^2 - 1)/2$

(C) $(5x^3 - 3x)/2$ (D) $(3x^2 + 1)/2$

Solid State Physics

55. The number of atoms per unit cell in a face-centred cubic (FCC) lattice is:

(A) 1 (B) 4

(C) 8 (D) 2

56. The coordination number of a body-centred cubic (BCC) lattice is:

(A) 12 (B) 6

(C) 4 (D) 8

57. A crystal plane makes intercepts a, 2b and ∞ on the three crystal axes. Its Miller indices are:

(A) (2 1 1) (B) (1 2 ∞)

(C) (1 2 0) (D) (2 1 0)

58. X-rays of wavelength 2 Å are diffracted by planes of spacing 2 Å. The first-order Bragg angle is:

(A) 30° (B) 45°

(C) 60° (D) 90°

59. The Meissner effect shows that a superconductor below its critical temperature:

(A) expels magnetic flux from its bulk

(B) becomes strongly ferromagnetic

(C) absorbs all the light falling on it

(D) shows a sharp rise in its resistance

60. The energy band gap of silicon at room temperature is:

(A) about 0.7 eV (B) about 1.1 eV

(C) about 5.5 eV (D) about 3.4 eV

61. According to the Dulong–Petit law, the molar heat capacity of a solid at high temperature is about:

(A) 5R/2 (B) R

(C) 3R/2 (D) 3R

Nuclear and Particle Physics

62. A radioactive sample has a half-life of 10 days. The fraction of the sample left undecayed after 30 days is:

(A) 1/4 (B) 1/8

(C) 1/3 (D) 1/6

63. The mean life τ and half-life $T_{1/2}$ of a radioactive nucleus are related as:

(A) $\tau = T_{1/2} \times \ln 2$ (B) $\tau = T_{1/2}/\ln 2$

(C) $\tau = T_{1/2}/2$ (D) $\tau = 2T_{1/2}$

64. In β^- decay, the atomic number Z and mass number A of the nucleus change as follows:

(A) Z increases by 1; A is unchanged

(B) Z is unchanged; A decreases by 1

(C) Z decreases by 1; A is unchanged

(D) Z and A both increase by 1

65. The ratio of the nuclear radius of a nucleus with A = 216 to that of a nucleus with A = 27 is:

(A) 3 (B) 4

(C) 8 (D) 2

66. The quark content of a proton is:

(A) uuu (B) uds

(C) uud (D) udd

67. Which of the following is NOT conserved in weak interactions?

(A) Baryon number (B) Energy

(C) Parity (D) Electric charge

68. The energy equivalent of one atomic mass unit (1 u) is about:

(A) 9.31 MeV (B) 0.511 MeV

(C) 931.5 MeV (D) 1.6×10^{-13} MeV

Electronics

69. A Zener diode operated in its reverse breakdown region is mainly used as a:

(A) voltage regulator (B) power amplifier

(C) half-wave rectifier (D) radio-frequency oscillator

70. The fundamental ripple frequency at the output of a full-wave rectifier fed from 50 Hz mains is:

(A) 100 Hz (B) 200 Hz

(C) 25 Hz (D) 50 Hz

71. For a transistor, the common-base current gain $\alpha = 0.98$. Its common-emitter current gain β is:

(A) 49 (B) 51

(C) 98 (D) 50

72. An ideal op-amp inverting amplifier has input resistance 10 kΩ and feedback resistance 100 kΩ. Its voltage gain is:

(A) −11 (B) +11

(C) −10 (D) +10

73. The Boolean expression A + AB simplifies to:

(A) A + B (B) A

(C) B (D) AB

74. The decimal equivalent of the binary number 1101.1 is:

(A) 11.5 (B) 13.25

(C) 27 (D) 13.5

75. For sustained oscillations, the Barkhausen criterion requires the loop gain Aβ of the feedback amplifier to be:

(A) 1, with a total phase shift of 0° or 360°

(B) less than 1, with a phase shift of 180°

(C) infinite, with a phase shift of 90°

(D) 0, with any phase shift

Answer Key

1	C	2	C	3	D	4	D	5	C	6	A	7	B	8	A	9	B	10	A
11	D	12	A	13	D	14	C	15	A	16	D	17	C	18	D	19	B	20	A
21	B	22	D	23	C	24	C	25	D	26	C	27	C	28	B	29	C	30	D
31	B	32	B	33	A	34	C	35	B	36	A	37	A	38	B	39	A	40	B
41	B	42	D	43	D	44	C	45	D	46	D	47	C	48	A	49	B	50	C
51	C	52	A	53	B	54	B	55	B	56	D	57	D	58	A	59	A	60	B
61	D	62	B	63	B	64	A	65	D	66	C	67	C	68	C	69	A	70	A
71	A	72	C	73	B	74	D	75	A										

Solutions

Mechanics and Special Relativity

1. (C) $v = dx/dt = 3t^2 - 12t + 9 = 3(t - 1)(t - 3)$, which is zero at $t = 1$ s and $t = 3$ s.

2. (C) $R = 2u^2 \sin\theta \cos\theta/g$ and $H = u^2 \sin^2\theta/2g$, so $R/H = 4 \cot \theta$. $R = 4H$ gives $\cot \theta = 1$, $\theta = 45°$.

3. (D) For a solid sphere $I = (2/5)MR^2$; $(2/3)MR^2$ is for a thin spherical shell and $(7/5)MR^2$ is about a tangent.

4. (D) Angular momentum L is conserved, so ω becomes 3ω. $K = L^2/2I$, and with $I \to I/3$ the kinetic energy becomes 3K (the extra energy comes from her muscular work).

5. (C) $v_e = \sqrt{(2GM/R)}$ and $v_0 = \sqrt{(GM/R)}$, so $v_0 = v_e/\sqrt{2}$.

6. (A) By Kepler's third law $T^2 \propto r^3$, so $T \propto r^{(3/2)} = 4^{(3/2)} = 8$.

7. (B) A rigid body has 3 translational and 3 rotational degrees of freedom.

8. (A) $L' = L\sqrt{(1 - v^2/c^2)} = L\sqrt{(1 - 0.64)} = 0.6L$.

9. (B) $\gamma = 1/\sqrt{(1 - 0.64)} = 1/0.6 = 5/3$, so the dilated lifetime is $\gamma\tau = 5\tau/3$.

10. (A) $E = \gamma m_0c^2 = 2m_0c^2$ gives $\gamma = 2$, so $v = c\sqrt{(1 - 1/4)} = (\sqrt{3}/2)c \approx 0.87c$.

Electricity and Magnetism

11. (D) A Gaussian sphere inside the shell encloses no charge, and by symmetry $E = 0$ everywhere inside.

12. (A) Gauss's law with a pillbox through the sheet gives $2EA = \sigma A/\varepsilon_0$, so $E = \sigma/2\varepsilon_0$, independent of distance.

13. (D) The charge Q stays fixed and C becomes KC, so $U = Q^2/2C$ becomes U/K.

14. (C) From the Biot–Savart law, each element contributes $\mu_0 I\, dl/4\pi R^2$; integrating over $2\pi R$ gives $\mu_0 I/2R$. ($\mu_0 I/2\pi R$ is for a long straight wire.)

15. (A) Ampère's law over a rectangular loop gives $BL = \mu_0 nLI$, so $B = \mu_0 nI$ ($\mu_0 nI/2$ is the value at an end).

16. (D) The induced emf opposes the change in flux that causes it (Lenz's law), as required by conservation of energy.

17. (C) Zero divergence of B means magnetic field lines have no sources or sinks, that is, isolated magnetic poles do not exist.

18. (D) Maxwell added $J_d = \varepsilon_0\, \partial E/\partial t$ to Ampère's law so that it holds for time-varying fields (σE is the conduction current density).

19. (B) S gives the rate of flow of electromagnetic energy per unit area, in W/m^2.

20. (A) $\omega_0 = 1/\sqrt{(LC)} = 1/\sqrt{(10^{-2} \times 10^{-6})} = 1/10^{-4} = 10^4$ rad/s.

Waves and Optics

21. (B) $\beta = \lambda D/d = (6 \times 10^{-7} \times 1)/(3 \times 10^{-4}) = 2 \times 10^{-3}$ m = 2.0 mm.

22. (D) For dark rings $D_n^2 = 4n\lambda R$, so $D_n \propto \sqrt{n}$.

23. (C) $\tan \theta_B = \mu = \sqrt{3}$, so $\theta_B = 60°$; the reflected light is then completely plane polarised.

24. (C) The first polariser passes $I_0/2$. By Malus's law the second passes $(I_0/2)\cos^2 60° = (I_0/2)(1/4) = I_0/8$.

25. (D) Resolving power $\lambda/d\lambda = nN$.

26. (C) Minima occur at $a \sin\theta = m\lambda$; for $m = 1$, $\sin\theta = \lambda/a$.

27. (C) $v = \sqrt{(T/\mu)}$.

28. (B) $v_g = v_p - \lambda\, dv_p/d\lambda$; with no dispersion $dv_p/d\lambda = 0$, so $v_g = v_p$.

Thermal and Statistical Physics

29. (C) $\eta = 1 - T_2/T_1 = 1 - 300/500 = 0.4 = 40\%$.

30. (D) $\Delta S = Q/T = nR \ln(V_2/V_1) = nR \ln 2$.

31. (B) $C_v = 3R/2$ and $C_p = 5R/2$, so $\gamma = 5/3$. (7/5 is for a diatomic gas.)

32. (B) Each of the three translational degrees of freedom has $(1/2)kT$, giving $(3/2)kT$.

33. (A) $v_{mp} = \sqrt{(2kT/m)}$, $v_{avg} = \sqrt{(8kT/\pi m)}$, $v_{rms} = \sqrt{(3kT/m)}$; since $2 < 8/\pi \approx 2.55 < 3$, $v_{mp} < v_{avg} < v_{rms}$.

34. (C) Half-integral spin particles (fermions) obey the Pauli principle and Fermi–Dirac statistics; integral-spin bosons obey Bose–Einstein statistics.

35. (B) By the Stefan–Boltzmann law $P \propto T^4$, so P becomes $2^4 = 16$ times.

36. (A) $dP/dT = L/[T(v_2 - v_1)]$ gives the slope of the coexistence curve in terms of latent heat.

37. (A) Nernst–Planck statement: the entropy of a perfect crystalline substance tends to zero as $T \to 0$ K.

Quantum Mechanics and Atomic Physics

38. (B) For electrons $\lambda = 12.27/\sqrt{V}$ Å $= 12.27/10 \approx 1.23$ Å.

39. (A) $K_{max} = h\nu - \phi = 4.0 - 2.0 = 2.0$ eV, so the stopping potential is 2.0 V.

40. (B) $E_1 = \pi^2\hbar^2/(2mL^2) \propto 1/L^2$, so doubling L makes E_1 one-fourth.

41. (B) $[x, p_x]\psi = x(-i\hbar\, d\psi/dx) - (-i\hbar)d(x\psi)/dx = i\hbar\psi$.

42. (D) $E_n = (n + \tfrac{1}{2})\hbar\omega$, so $E_{(n+1)} - E_n = \hbar\omega$. The zero-point energy is $\hbar\omega/2$.

43. (D) $E_n = -13.6/n^2$ eV $= -13.6/4 = -3.4$ eV (-1.51 eV is for $n = 3$).

44. (C) Splitting in a magnetic field is the Zeeman effect; in an electric field it is the Stark effect.

45. (D) By the Pauli exclusion principle a shell holds $2n^2$ electrons: $2 \times 9 = 18$.

46. (D) $\int|\psi|^2dx = A^2 \times 2\int_0^{\infty} e^{(-2x/a)}dx = A^2 \times 2 \times (a/2) = A^2a = 1$, so $A = 1/\sqrt{a}$.

47. (C) $\Delta\lambda = (h/m_0c)(1 - \cos\theta)$ is largest at $\theta = 180°$, giving $2h/(m_0c) \approx 4.85$ pm.

Mathematical Physics

48. (A) The curl of a gradient is always the zero vector (mixed partial derivatives are equal).

49. (B) $\nabla\cdot r = \partial x/\partial x + \partial y/\partial y + \partial z/\partial z = 1 + 1 + 1 = 3$.

50. (C) The volume integral of the divergence equals the outward flux through the closed surface. The second option is Stokes' theorem.

51. (C) $\det(A - \lambda I) = (2 - \lambda)^2 - 1 = 0$ gives $\lambda = 1$ and $\lambda = 3$ (sum 4 = trace, product 3 = determinant).

52. (A) $f(x) = x$ is an odd function, so a_0 and all a_n vanish and only sine terms remain: $x = 2\Sigma(-1)^{(n+1)} \sin(nx)/n$.

53. (B) $L\{\sin at\} = a/(s^2 + a^2)$; $s/(s^2 + a^2)$ is the transform of $\cos at$.

54. (B) $P_0 = 1$, $P_1 = x$, $P_2 = (3x^2 - 1)/2$, $P_3 = (5x^3 - 3x)/2$. Check: $P_2(1) = 1$.

Solid State Physics

55. (B) 8 corners × 1/8 + 6 face centres × 1/2 = 1 + 3 = 4.

56. (D) The body-centre atom touches the 8 corner atoms. (FCC has 12, simple cubic 6.)

57. (D) Intercepts in units of a, b, c: 1, 2, ∞. Reciprocals: 1, 1/2, 0. Clearing fractions gives (2 1 0).

58. (A) $2d \sin\theta = n\lambda$ gives $\sin\theta = 2/(2 \times 2) = 0.5$, so $\theta = 30°$.

59. (A) A superconductor is a perfect diamagnet ($\chi = -1$): magnetic flux is expelled from its interior.

60. (B) Silicon has Eg ≈ 1.1 eV; germanium ≈ 0.67 eV, GaN ≈ 3.4 eV and diamond ≈ 5.5 eV.

61. (D) Each atom has 3 vibrational modes, each with energy kT, so U = 3RT per mole and C = 3R ≈ 25 J mol^{-1} K^{-1}.

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62. (B) 30 days = 3 half-lives, so the fraction left is $(1/2)^3 = 1/8$.

63. (B) $\tau = 1/\lambda$ and $T_{1/2} = \ln 2/\lambda$, so $\tau = T_{1/2}/\ln 2 \approx 1.44\ T_{1/2}$.

64. (A) A neutron changes into a proton ($n \rightarrow p + e^- + \bar{\nu}$), so Z rises by 1 and A stays the same.

65. (D) $R = R_0A\text{^}(1/3)$, so the ratio is (216/27)^(1/3) = 8^(1/3) = 2.

66. (C) Proton = uud (charge 2/3 + 2/3 − 1/3 = +1); neutron = udd.

67. (C) Wu's 1957 experiment on cobalt-60 beta decay showed that parity is violated in weak interactions.

68. (C) 1 u × c^2 ≈ 931.5 MeV; 0.511 MeV is the rest energy of an electron.

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69. (A) In breakdown the Zener voltage stays nearly constant over a wide range of current, so it regulates voltage.

70. (A) A full-wave rectifier gives two output pulses per input cycle, so the ripple frequency is 2 × 50 = 100 Hz.

71. (A) $\beta = \alpha/(1 - \alpha) = 0.98/0.02 = 49$.

72. (C) Gain = −Rf/Rin = −100/10 = −10. (+11 would be the non-inverting gain 1 + Rf/Rin.)

73. (B) A + AB = A(1 + B) = A × 1 = A (absorption law).

74. (D) 1101 = 8 + 4 + 0 + 1 = 13 and .1 = 1/2, so 13.5.

75. (A) The loop gain must be exactly unity in magnitude, with the total phase shift around the loop equal to 0° or 360° (positive feedback).