PhysicsByAaryan

TIFR Physics 2017

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Atomic and Molecular Physics

Q1. [TIFR_2017_A_Q12]
Year 2017 · Atomic and Molecular Physics · Molecular Physics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

The separation between neighbouring absorption lines in a pure rotational spectrum of the hydrogen bromide (HBr) molecule is 2.23 meV. If this molecule is considered as a rigid rotor and the atomic mass number of Br is 80, the corresponding absorption line separation in deuterium bromide (DBr) molecule, in units of meV, would be

(a) 2.234
(b) 1.115
(c) 1.128
(d) 4.461

Q2. [TIFR_2017_A_Q22]

Year 2017 · Atomic and Molecular Physics · Bohar model · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

The energy of an electron in the ground state of the He atom is -79 eV . Considering the Bohr model of the atom, what would be 10 times the first ionization potential for a He^{+}ion, in units of eV ?

Q3. [TIFR_2017_C_Q6]

Year 2017 · Atomic and Molecular Physics · Bohar model · Only PhD · 5 marks

TIFR GS	2017	Section C

Hydrogen atoms in the atmosphere of a star are in thermal equilibrium, with an average kinetic energy of 1 eV . The ratio of the number of hydrogen atoms in the 2nd excited state ($n = 3$) to the number in the ground state ($n = 1$) is

(a) 3.16×10^{-11}

(b) 1.33×10^{-8}

(c) 3.16×10^{-8}

(d) 5.62×10^{-6}

Classical Mechanics

Q4. [TIFR_2017_A_Q17]

Year 2017 · Classical Mechanics · Central Forces, Gravitation and Universe · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A space telescope in orbit around the Earth discovers a new planet, which is observed to move around the Sun by an angle of 4.72 milliradians in a year. Assuming a circular orbit, estimate the distance, in A.U., of the planet from the Sun.

Q5. [TIFR_2017_A_Q23]

Year 2017 · Classical Mechanics · Special Theory of Relativity · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

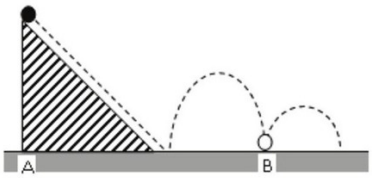
Cosmic ray muons, which decay spontaneously with proper lifetime $2.2\,\mu s$, are produced in the atmosphere, at a height of 5 km above sea level. These move straight downwards at 98% of the speed of light. Find the percent ratio $100 \times (N_A/N_B)$ of the number of muons measured at the top of two mountains A and B , which are at heights $4{,}848\ \mathrm{m}$ and $2{,}682\ \mathrm{m}$ respectively above mean sea level.

Q6. [TIFR_2017_A_Q4]

Year 2017 · Classical Mechanics · Basic Mechanics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A small elastic ball of mass m is placed at the apex of a 45° inclined plane as shown in the figure below.



The ball is allowed to slip without friction down the plane (along the dotted line), hit the ground (as shown) and bounce along it. If the height of the inclined plane is h and the coefficient of restitution between the ball and the ground is 0.5, then the distance AB, as marked on the figure, will be

(a) 3h

(b) 2h

(c) $(1+\sqrt{2})\mathrm{h}$

(d) $3\sqrt{2}\mathrm{h}$

Q7. [TIFR_2017_A_Q5]

Year 2017 · Classical Mechanics · Oscillations · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

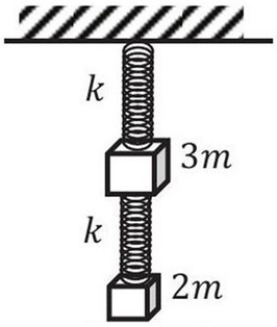
Two masses 3m and 2m are suspended vertically by identical massless springs, each of stiffness constant k. The mass 2m is suspended from the mass 3m and the mass 3m is suspended from a rigid support, as shown in the figure. If only vertical motion is permitted, the frequencies of small oscillations of this system are

(a) $\sqrt{\frac{\mathrm{k}}{\mathrm{m}}}, \sqrt{\frac{\mathrm{k}}{6\mathrm{m}}}$

(b) $\sqrt{\frac{\mathrm{k}}{2\mathrm{m}}}, \sqrt{\frac{\mathrm{k}}{3\mathrm{m}}}$

(c) $\sqrt{\frac{\mathrm{k}}{\mathrm{m}}}, \sqrt{\frac{3\mathrm{k}}{2\mathrm{m}}}$

(d) $\sqrt{\frac{2\mathrm{k}}{3\mathrm{m}}}, \sqrt{\frac{3\mathrm{k}}{2\mathrm{m}}}$



Q8. [TIFR_2017_B_Q3]

Year 2017 · Classical Mechanics · Rotational Motion · Only int. Phd · 5 marks

TIFR GS	2017	Section B

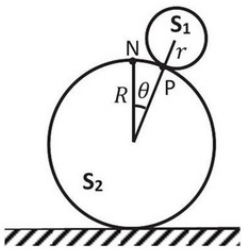
A uniform solid sphere S_1 of radius r and mass m is rolling without slipping on top of another sphere S_2 of radius R, as shown in the figure. Initially, S_1 was at rest directly on top of S_2, and then it started rolling down under the influence of gravity. The point of contact P subtends an instantaneous angle θ from the topmost point N of the lower sphere at the centre of the lower sphere. At what minimum value of θ will the spheres lose contact?

(a) $\cos^{-1}\frac{5}{12}$

(b) $\cos^{-1}\frac{5}{13}$

(c) $\cos^{-1}\frac{2}{3}$

(d) $\cos^{-1}\frac{12}{13}$



Q9. [TIFR_2017_C_Q2]

Year 2017 · Classical Mechanics · Lagrangian and Hamiltonian · Only PhD · 5 marks

TIFR GS	2017	Section C

The Lagrangian of a system described by a single generalised coordinate q is

$$L = \frac{1}{2}\dot{q}\sin^2 q$$

Its Hamiltonian is

(a) not defined

(b) Zero

(c) $-\dot{q}\sin^2 q$

(d) $\dot{q}\left(p - \frac{1}{2}\sin^2 q\right)$

Q10. [TIFR_2017_C_Q9]

Year 2017 · Classical Mechanics · Central Forces, Gravitation and Universe · Only PhD · 5 marks

TIFR GS	2017	Section C

The cosmic microwave background radiation in the Universe has a blackbody distribution corresponding to a temperature 2.735 K. In a certain cosmological model, it was assumed that the universe consists purely of radiation and is undergoing adiabatic expansion. In this model it was predicted that the volume of the Universe will be tripled in the next 10^{10} yrs. The corresponding blackbody radiation temperature would be

(a) 0.9116 K

(b) 2.078 K

(c) 1.896 K

(d) 1.526 K

Electromagnetism

Q11. [TIFR_2017_A_Q24]

Year 2017 · Electromagnetism · EM Waves · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

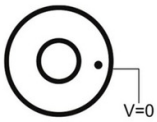
A signal is to be sent from a coaxial cable with impedance $40\,\Omega$ into a second coaxial cable with impedance $60\,\Omega$. We can prevent reflection at the joint between the cables, by adding an impedance in parallel to the second cable. What should be the value, in units of Ohms (Ω), of that impedance?

Q12. [TIFR_2017_A_Q6]

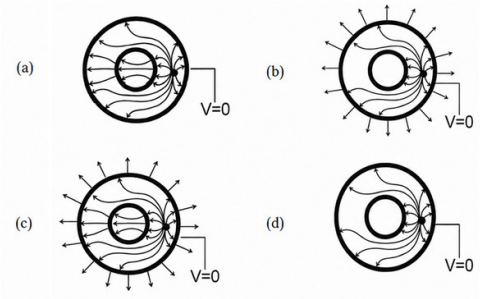
Year 2017 · Electromagnetism · Electrostatics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

Two long hollow conducting cylinders, each of height h, are placed concentrically on the ground, as shown in the figure (top view). The outer cylinder is grounded, while the inner cylinder is insulated. A positive charge (the black dot in the figure) is placed between the cylinders at a height $h/2$ from the ground.



Which of the following figures gives the most accurate representation (top view) of the lines of force?



Q13. [TIFR_2017_A_Q7]

Year 2017 · Electromagnetism · Electrostatics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A common model for the distribution of charge in a hydrogen atom has a point-like proton of charge $+q_0$ at the centre and an electron with a static charge density distribution

$$\rho(r) = -\frac{q_0}{\pi a^3} e^{-2r/a}$$

where a is a constant. The electric field $\vec{E}$ at $r = a$ due to this system of charges will be

(a) $-\frac{5q_0}{4\pi\epsilon_0 e^2 a^2}\hat{r}$

(b) $-\frac{5q_0}{4\pi\epsilon_0 e a^2}\hat{r}$

(c) $\frac{5q_0}{4\pi\epsilon_0 e^2 a^2}\hat{r}$

(d) $\frac{3q_0}{4\pi\epsilon_0 e^2 a^2}\hat{r}$

Q14. [TIFR_2017_A_Q8]

Year 2017 · Electromagnetism · Electrodynamics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A rectangular metallic loop with sides L_1 and L_2 is placed in the vertical plane, making an angle φ with respect to the x-axis, as shown in the figure, and a spatially uniform magnetic field $\vec{B} = B\hat{y}$ is applied. The loop is free to rotate about the $\hat{z}$ axis (shown in the figure with a double line). The magnetic field changes with time at a constant rate

$$\frac{dB}{dt} = \kappa$$

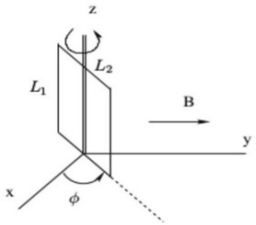
If the resistance of the loop is R, the torque τ required to prevent the loop from rotating will be

(a) $-\kappa B\frac{(L_1L_2)^2}{2R}\sin 2\varphi\,\hat{z}$

(b) $\kappa B\frac{(L_1L_2)^2}{R}\sin\varphi\cos\varphi\,\hat{z}$

(c) $\kappa B\frac{(L_1L_2)^2}{2R}\sin\varphi\,\hat{z}$

(d) $-\kappa B\frac{(L_1L_2)^2}{R}\sin\varphi\,\hat{z}$



Q15. [TIFR_2017_B_Q4]

Year 2017 · Electromagnetism · EM Waves · Only int. Phd · 5 marks

TIFR GS	2017	Section B

An electromagnetic wave in free space is described by

$$\vec{E}(x,y,z,t) = \hat{z}E_0\cos\frac{1}{2}(kx - \sqrt{3}ky - 2\omega t)$$

The Poynting vector associated with this wave is along the direction

(a) $\hat{x} + \sqrt{3}\hat{y}$

(b) $\sqrt{3}\hat{x} + \hat{y}$

(c) $-\sqrt{3}\hat{x} + \hat{y}$

(d) $\hat{x} - \sqrt{3}\hat{y}$

Q16. [TIFR_2017_C_Q4]

Year 2017 · Electromagnetism · Electrostatics · Only PhD · 5 marks

TIFR GS	2017	Section C

Consider a spherical shell with radius R such that the potential on the surface of the shell in spherical coordinates is given by,

$$V(r = R, \theta, \varphi) = V_0 \cos^2 \theta$$

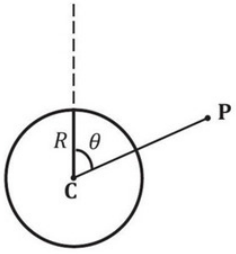
where the angle θ is shown in the figure. There are no charges except for those on the shell. The potential outside the shell at the point P a distance 2R away from its center C (see figure) is

(a) $V = \frac{V_0}{8}(1 + \cos^2 \theta)$

(b) $V = \frac{V_0}{4}(1 - \cos^2 \theta)$

(c) $V = \frac{V_0}{8}(1 + 2\cos^2 \theta)$

(d) $V = \frac{V_0}{2}(-2\cos \theta + \cos^3 \theta)$



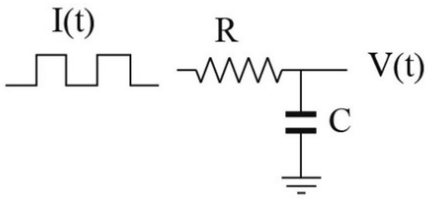
Electronics

Q17. [TIFR_2017_A_Q14]

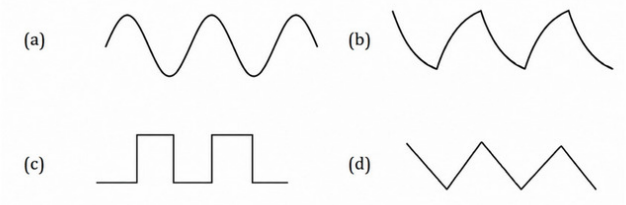
Year 2017 · Electronics · Filters · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A current source produces a square wave I(t) of 1.0 V peak-to-peak voltage and is used to drive the RC circuit shown below.



Which of the following represents the correct voltage across the capacitor C ?

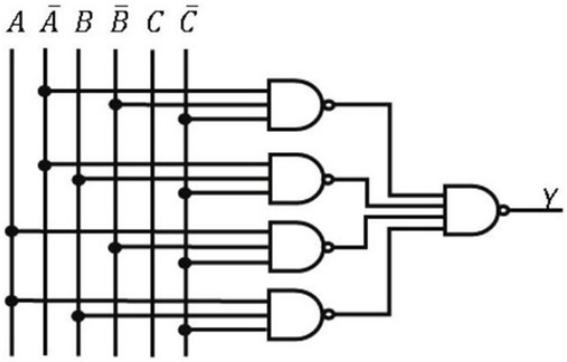


Q18. [TIFR_2017_A_Q15]

Year 2017 · Electronics · Logic Gates · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

The output (Y) of the following circuit will be



(a) $\bar{A} + B + \bar{C}$

(b) $\bar{A}$

(c) $\bar{B}$

(d) $\bar{C}$

Q19. [TIFR_2017_B_Q10]

Year 2017 · Electronics · Logic Gates · Only int. Phd · 5 marks

TIFR GS	2017	Section B

For exact calculation and minimum complexity, two four-digit binary numbers can be added with

(a) 1 full adder and 3 half-adders

(b) 2 full adders and 2 half-adders

(c) 3 full adders and 1 half-adder

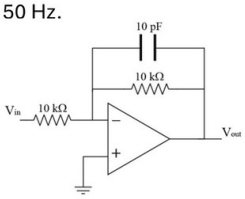
(d) 4 full adders

Q20. [TIFR_2017_C_Q10]

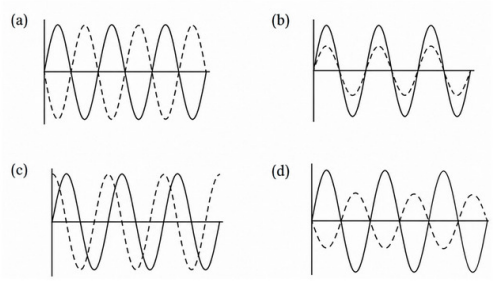
Year 2017 · Electronics · OPAMP · Only PhD · 5 marks

TIFR GS	2017	Section C

The following circuit is fed with an input sine wave of frequency 50 Hz.



Which of the following graphs (solid line is input and dashed line is output) best represents the correct situation?



Experimental Physics

Q21. [TIFR_2017_A_Q25]

Year 2017 · Experimental Physics · Instruments · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

An AC voltage source has an internal resistance of 50 Ω and is specified to deliver an rms voltage of 50 V to a matched load. If you connect this AC source to a cathode-ray oscilloscope with 1 MΩ input setting, what will be the peak-to-peak voltage you observe?

Q22. [TIFR_2017_B_Q2]

Year 2017 · Experimental Physics · Error Analysis · Only int. Phd · 5 marks

TIFR GS	2017	Section B

A liquid is flowing through a capillary tube of inner radius r under the influence of an external pressure P. The uncertainties in the measurements of P and r are found to be 2% and 1%, respectively. The uncertainty in the flow of liquid per second is

(a) 4.47%

(b) 2.23%

(c) 2.83%

(d) 3.61%

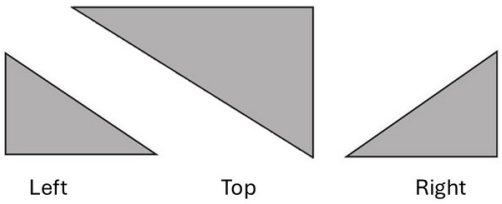
Geometry

Q23. [TIFR_2017_A_Q3]

Year 2017 · Geometry · Geometry · Both int. phd and phd · 3 marks

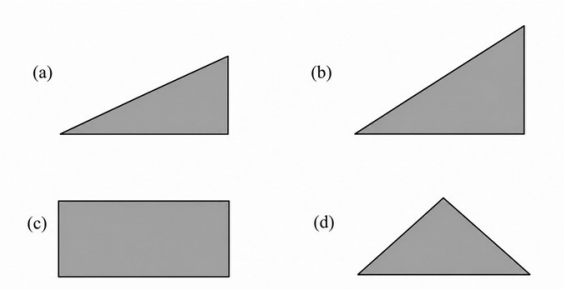
TIFR GS	2017	Section A

A solid tetrahedron (solid with four plane sides) has the following projections (drawn to scale) when seen from three different sides:



Left Top Right

When viewed from the front, its projection will be



Mathematical Physics

Q24. [TIFR_2017_A_Q1]

Year 2017 · Mathematical Physics · Matrices · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

Denote the commutator of two matrices A and B by $[A, B] = AB - BA$ and the anti-commutator by $\{A, B\} = AB + BA$. If $\{A, B\} = 0$,we can write $[A, BC] =$

(a) $-B[A, C]$

(b) $B\{A, C\}$

(c) $-B\{A, C\}$

(d) $[A, C]B$

Q25. [TIFR_2017_A_Q16]

Year 2017 · Mathematical Physics · Matrices · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

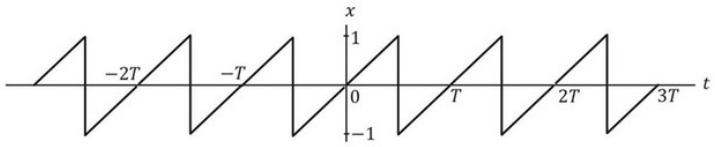
The matrix $\begin{pmatrix} 100\sqrt{2} & x & 0 \\ -x & 0 & -x \\ 0 & x & 100\sqrt{2} \end{pmatrix}$ where $x > 0$, is known to have two equal eigenvalues. Find the value of x.

Q26. [TIFR_2017_A_Q2]

Year 2017 · Mathematical Physics · Fourier and Laplace Analysis · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

Consider the waveform x(t) shown in the diagram below.



The Fourier series for x(t) which gives the closest approximation to this waveform is

(a) $x(t) = \frac{2}{\pi}\left[\cos\frac{\pi t}{T} - \frac{1}{2}\cos\frac{4\pi t}{T} + \frac{1}{3}\cos\frac{3\pi t}{T} + \cdots\right]$

(b) $x(t) = \frac{2}{\pi}\left[-\sin\frac{\pi t}{T} + \frac{1}{2}\sin\frac{2\pi t}{T} - \frac{1}{3}\sin\frac{3\pi t}{T} + \cdots\right]$

(c) $x(t) = \frac{2}{\pi}\left[\sin\frac{\pi t}{T} - \frac{1}{2}\sin\frac{2\pi t}{T} + \frac{1}{3}\sin\frac{3\pi t}{T} + \cdots\right]$

(d) $x(t) = \frac{2}{\pi}\left[-\cos\frac{2\pi t}{T} + \frac{1}{2}\cos\frac{4\pi t}{T} - \frac{1}{3}\cos\frac{6\pi t}{T} + \cdots\right]$

Q27. [TIFR_2017_B_Q1]

Year 2017 · Mathematical Physics · Matrices · Only int. Phd · 5 marks

TIFR GS	2017	Section B

A unitary matrix U is expanded in terms of a Hermitian matrix H, such that

$$U = e^{i\pi H/2}$$

If we know that

$$H = \begin{pmatrix} 1/2 & 0 & \sqrt{3}/2 \\ 0 & 1 & 0 \\ \sqrt{3}/2 & 0 & -1/2 \end{pmatrix}$$

then U must be

(a) $\begin{pmatrix} i & 1/2 & \sqrt{3}/2 \\ 1/2 & i & 1/2 \\ \sqrt{3}/2 & 1/2 & i \end{pmatrix}$

(b) $\begin{pmatrix} i/2 & 0 & i\sqrt{3}/2 \\ 0 & i & 0 \\ i\sqrt{3}/2 & 0 & -i/2 \end{pmatrix}$

(c) $\begin{pmatrix} 1 & 0 & \sqrt{3} \\ 0 & 2 & 0 \\ \sqrt{3} & 0 & -1 \end{pmatrix}$

(d) $\begin{pmatrix} 2i & 1 & \sqrt{3}/2 \\ 1 & 2i & 0 \\ \sqrt{3}/2 & 0 & 2i \end{pmatrix}$

Q28. [TIFR_2017_C_Q1]

Year 2017 · Mathematical Physics · Complex Analysis · Only PhD · 5 marks

TIFR GS	2017	Section C

The value of the integral $\int_0^{\infty} \frac{dx}{x^4+4}$ is

(a) π

(b) $\frac{\pi}{2}$

(c) $\frac{\pi}{4}$

(d) $\frac{\pi}{8}$

Nuclear and Particle Physics

Q29. [TIFR_2017_B_Q8]

Year 2017 · Nuclear and Particle Physics · Radioactivity · Only int. Phd · 5 marks

TIFR GS	2017	Section B

A deuteron of mass M and binding energy B is struck by a gamma ray photon of energy E_γ, and is observed to disintegrate into a neutron and a proton. If $B \ll Mc^2$, the minimum value of E_γ must be

(a) $2B + \frac{B^2}{2Mc^2}$

(b) $B + \frac{B^2}{Mc^2}$

(c) $\frac{1}{2}\left(3B + \frac{B^2}{Mc^2}\right)$

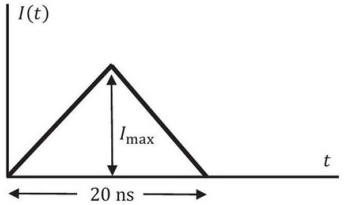
(d) $\frac{1}{2}\left(2B + \frac{B^2}{Mc^2}\right)$

Q30. [TIFR_2017_C_Q7]

Year 2017 · Nuclear and Particle Physics · Accelerator and Detectors · Only PhD · 5 marks

TIFR GS	2017	Section C

A photomultiplier tube is used to detect identical light pulses each of which consists of a fixed number of photons. The photoelectric efficiency is 10%, i.e. a photon has 10% probability of causing the emission of a detectable photoelectron. The photomultiplier gain is 10^6.



The typical output current, as a function of time, is shown by the figure below for a few pulses, where I_{max} is 80 μA. It follows that the number of photons in each pulse is

(a) 5×10^6
(b) 5
(c) 800
(d) 50

Q31. [TIFR_2017_C_Q8]

Year 2017 · Nuclear and Particle Physics · Particle Physics · Only PhD · 5 marks

TIFR GS	2017	Section C

A subatomic particle ψ and its excited state ψ^* have rest masses $3.1\ \mathrm{GeV/c^2}$ and $3.7\ \mathrm{GeV/c^2}$ respectively. A table of its assigned quantum numbers is given below.

Angular Momentum	Parity	C-Parity	Isospin	Electric charge
$J = 1$	$P = -1$	$C = -1$	$I = 0$	$Q = 0$

If π^{0*} is an excited state of π^0 with a mass of about $1.3\ \mathrm{GeV/c^2}$, which of the following reactions is possible when the above quantum numbers are conserved?

(a) $\psi^* \rightarrow \gamma\gamma$
(b) $\psi^* \rightarrow \psi\pi^+\pi^-$
(c) $\psi^* \rightarrow \pi^0\pi^0$
(d) $\psi^* \rightarrow \psi\pi^{0*}$

Optics

Q32. [TIFR_2017_A_Q20]

Year 2017 · Optics · Ray Optics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

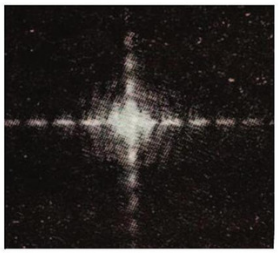
A beam of plane microwaves of wavelength 12 cm strikes the surface of a dielectric at 45°. If the refractive index of the dielectric is 4/3, what will be the wavelength, in units of mm, of the microwaves inside the dielectric?

Q33. [TIFR_2017_B_Q9]

Year 2017 · Optics · Diffraction · Only int. Phd · 5 marks

TIFR GS	2017	Section B

Light passes through a narrow slit and gives the Fraunhofer diffraction pattern shown in the adjacent figure.



Which of the following could be the shape of the slit?

(a) 

(c) 

(b) 

(d) 

Quantum Mechanics

Q34. [TIFR_2017_A_Q10]

Year 2017 · Quantum Mechanics · Basic Quantum Mechanics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

The normalized wave function of a particle can be written as

$$\Psi(x) = N\sum_{n=0}^{\infty}\left(\frac{1}{\sqrt{7}}\right)^{n}\varphi_n(x)$$

where $\varphi_n(x)$ are the normalized energy eigenfunctions of a given Hamiltonian. The value of N is

(a) $\sqrt{1/7}$

(b) $\sqrt{6/7}$

(c) $\sqrt{3/7}$

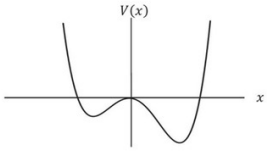
(d) $\sqrt{(6-2\sqrt{7})/7}$

Q35. [TIFR_2017_A_Q9]

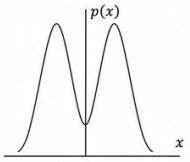
Year 2017 · Quantum Mechanics · Potential Well · Both int. phd and phd · 3 marks

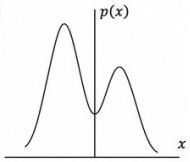
TIFR GS	2017	Section A

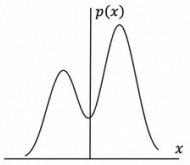
Consider the 1-D asymmetric double-well potential $V(x)$ as sketched below.

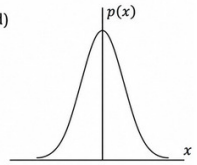


The probability distribution $p(x)$ of a particle in the ground state of this potential is best represented by

(a)


(b)


(c)


(d)


Q36. [TIFR_2017_B_Q5]

Year 2017 · Quantum Mechanics · Angular Momentum and Hydrogen atom · Only int. Phd · 5 marks

TIFR GS	2017	Section B

Electrons in a given system of hydrogen atoms are described by the wave function

$$\psi(r,\theta,\varphi) = 0.8\Psi_{100} + 0.6e^{i\pi/3}\Psi_{311}$$

where the $\Psi_{n\ell m}$ denote normalized energy eigenstates. If ($\hat{L}_x, \hat{L}_y, \hat{L}_z$) are the components of the orbital angular momentum operator, the expectation value of $\hat{L}_x^2$ in this system is

(a) $1.5\hbar^2$

(b) $0.36\hbar^2$

(c) $0.18\hbar^2$

(d) Zero

Q37. [TIFR_2017_C_Q5]

Year 2017 · Quantum Mechanics · Pertubation theory · Only PhD · 5 marks

TIFR GS	2017	Section C

A quantum mechanical system which has stationary states $|1\rangle, |2\rangle$ and $|3\rangle$, corresponding to energy levels $0eV, 1eV$ and 2 eV respectively, is perturbed by a potential of the form

$$\hat{V} = \varepsilon|1\rangle\langle 3| + \varepsilon|3\rangle\langle 1|$$

where, in $eV, 0 < \varepsilon \ll 1$. The new ground state, correct to order ε, is approximately.

(a) $\left(1 - \frac{\varepsilon}{2}\right)|1\rangle + \frac{\varepsilon}{2}|3\rangle$

(b) $|1\rangle + \frac{\varepsilon}{2}|2\rangle - \varepsilon|3\rangle$

(c) $|1\rangle + \frac{\varepsilon}{2}|3\rangle$

(d) $|1\rangle - \frac{\varepsilon}{2}|3\rangle$

Solid State Physics

Q38. [TIFR_2017_A_Q13]

Year 2017 · Solid State Physics · Lattice Vibrations and Thermal Properties · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

Consider a 2-D square lattice. The ratio of the kinetic energy of a free electron at a corner of the first Brillouin zone (E_c) to that of an electron at the midpoint of a side face of the same zone (E_m) is $E_c/E_m =$

(a) $1/2$

(b) 2

(c) $\sqrt{2}$

(d) 1

Q39. [TIFR_2017_B_Q6]

Year 2017 · Solid State Physics · Lattice Vibrations and Thermal Properties · Only int. Phd · 5 marks

TIFR GS	2017	Section B

In two dimensions, two metals A and B , have the number density of free electrons in the ratio

$$n_A : n_B = 1 : 2$$

The ratio of their Fermi energies is

(a) 2: 3

(b) 1: 2

(c) 1: 4

(d) 1: 8

Statistical Mechanics

Q40. [TIFR_2017_A_Q11]

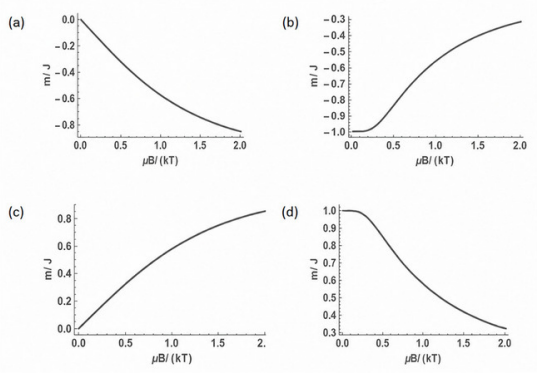
Year 2017 · Statistical Mechanics · Canonical Ensemble · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

Consider a system of non-interacting particles with integer angular momentum J at a temperature T. This system is placed in a magnetic field B in the z direction. The energy of a state with $J_z = m\hbar$ is

$$E_m = m\mu_B B$$

with $\mu_B > 0$. The fractional magnetization of the particles as a function of $\mu_B B/k_B T$ can be represented as



Q41. [TIFR_2017_A_Q18]

Year 2017 · Statistical Mechanics · Canonical Ensemble · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A system of particles occupying single-particle levels and obeying Maxwell-Boltzmann statistics is in thermal equilibrium with a heat reservoir at temperature T. If the population distribution in the non-degenerate energy levels is as shown in the table below, what would be the temperature of the system in degree Kelvin?

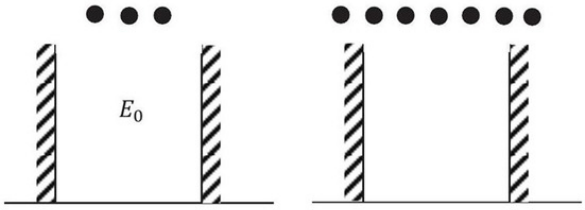
Energy (eV)	Population %
30.30	3.16
21.60	8.69
13.01	23.54
4.31	64.61

Q42. [TIFR_2017_A_Q21]

Year 2017 · Statistical Mechanics · Microstates · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A quantum mechanical system consists of a one-dimensional infinite box, as indicated in the figures below.



3 (three) identical non-interacting spin-$\frac{1}{2}$ particles, are first placed in the box, and the ground state energy of the system is found to be $\mathrm{E_0} = 18\,\mathrm{eV}$. If 7 (seven) such identical particles are placed in the box, what will be the ground state energy, in units of eV ?

Q43. [TIFR_2017_C_Q3]

Year 2017 · Statistical Mechanics · Canonical Ensemble · Only PhD · 5 marks

TIFR GS	2017	Section C

A one-dimensional quantum harmonic oscillator of natural frequency ω is in thermal equilibrium with a heat bath at temperature T. The mean value $\langle \mathrm{E} \rangle$ of the energy of the oscillator can be written as

(a) $\frac{\hbar\omega}{2}\,\mathrm{sech}\left(\frac{\hbar\omega}{2\mathrm{k_B T}}\right)$

(b) $\frac{\hbar\omega}{2}\,\mathrm{csch}\left(\frac{\hbar\omega}{2\mathrm{k_B T}}\right)$

(c) $\frac{\hbar\omega}{2}\coth\left(\frac{\hbar \mathrm{w}}{2\mathrm{k_B T}}\right)$

(d) $\frac{\hbar\omega}{2}\tanh\left(\frac{\hbar\omega}{2\mathrm{k_B T}}\right)$

Thermodynamics

Q44. [TIFR_2017_A_Q19]

Year 2017 · Thermodynamics · Laws of thermodynamics · Both int. phd and phd · 3 marks

TIFR GS	2017	Section A

A thermally isolated container stores N_2 gas at 27.24°C at one atmospheric pressure. Suddenly the pressure of the gas is increased to two atmospheric pressures. Assuming N_2 to behave as an ideal gas, estimate the change in temperature of the gas, in Celsius degrees (°C).

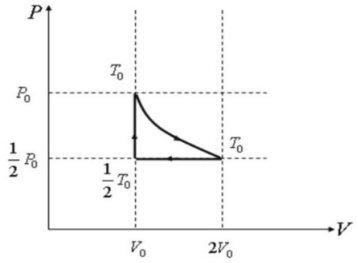
Q45. [TIFR_2017_B_Q7]

Year 2017 · Thermodynamics · Carnot Cycle · Only int. Phd · 5 marks

TIFR GS	2017	Section B

One mole of monoatomic ideal gas is initially at pressure P_0 and volume V_0. The gas then undergoes a three-stage cycle consisting of the following processes:

i) An isothermal expansion till it reaches volume $2V_0$, and heat Q flows into the gas
ii) An isobaric compression back to the original volume V_0
iii) An isochoric increase in pressure till the original pressure P_0 is regained.



The corresponding P − V diagram is shown above.

The efficiency of this cycle can be expressed as

(a) $\epsilon = \frac{4Q+2RT_0}{4Q+RT_0}$

(b) $\epsilon = \frac{4Q+2RT_0}{4Q-3RT_0}$

(c) $\epsilon = \frac{4Q-2RT_0}{4Q+RT_0}$

(d) $\epsilon = \frac{4Q-2RT_0}{4Q+3RT_0}$

Answer Key & Index

Complete TIFR GS Physics Paper · 2017 · 45 questions

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2	TIFR_2017_A_Q22	Atomic and Molecular Physics	Bohar model	246	3
3	TIFR_2017_C_Q6	Atomic and Molecular Physics	Bohar model	b	5
4	TIFR_2017_A_Q17	Classical Mechanics	Central Forces, Gravitation an	121	3
5	TIFR_2017_A_Q23	Classical Mechanics	Special Theory of Relativity	052	3
6	TIFR_2017_A_Q4	Classical Mechanics	Basic Mechanics	b	3
7	TIFR_2017_A_Q5	Classical Mechanics	Oscillations	a	3
8	TIFR_2017_B_Q3	Classical Mechanics	Rotational Motion	a	5
9	TIFR_2017_C_Q2	Classical Mechanics	Lagrangian and Hamiltonian	a	5
10	TIFR_2017_C_Q9	Classical Mechanics	Central Forces, Gravitation an	c	5
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13	TIFR_2017_A_Q7	Electromagnetism	Electrostatics	c	3
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38	TIFR_2017_A_Q13	Solid State Physics	Lattice Vibrations and Thermal	b	3
39	TIFR_2017_B_Q6	Solid State Physics	Lattice Vibrations and Thermal	b	5
40	TIFR_2017_A_Q11	Statistical Mechanics	Canonical Ensemble	a	3
41	TIFR_2017_A_Q18	Statistical Mechanics	Canonical Ensemble	MTA	3
42	TIFR_2017_A_Q21	Statistical Mechanics	Microstates	132	3
43	TIFR_2017_C_Q3	Statistical Mechanics	Canonical Ensemble	c	5
44	TIFR_2017_A_Q19	Thermodynamics	Laws of thermodynamics	066	3
45	TIFR_2017_B_Q7	Thermodynamics	Carnot Cycle	d	5