DU PHYSICS 2016 PAPER

1. In a collision between two particles
(a) linear momentum is conserved, but kinetic energy is not necessarily conserved
(b) kinetic energy is conserved, but linear momentum is not necessarily conserved
(c) either linear momentum or kinetic energy, but not necessarily both are conserved.
(d) both linear momentum and kinetic energy are conserved.

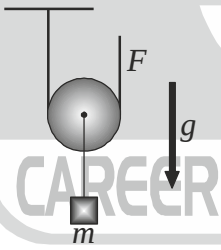
2. The moment of inertia of a thin rectangular plate of length a, width b, mass m about an axis passing through the centre and perpendicular to the plate is

(a) $\frac{1}{12}m\left(a^2+b^2\right)$ (b) $\frac{1}{6}m\left(a^2+b^2\right)$ (c) $\frac{1}{12}mab$ (d) $\frac{1}{6}mab$

3. A smooth sphere rests on a horizontal plane. A point particle slides without friction down the sphere, starting at the top. If R be the radius of the sphere, the velocity of the particle when it leaves the surface would be given by (g is the acceleration due to gravity)

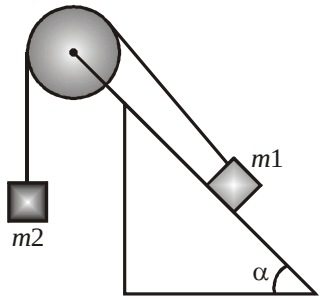
(a) $\sqrt{\frac{2gR}{3}}$ (b) $\sqrt{\frac{3gR}{2}}$ (c) $\sqrt{\frac{3gR}{4}}$ (d) $\sqrt{\frac{4gR}{3}}$

4. A mass m is suspended from a frictionless pulley and hangs over an inextensible string attached to the ceiling on one side and a force F is exerted upwards at the other end as shown in the figure below. The force F for the condition of static equilibrium is



(a) 1 mg (b) 2 mg (c) 4 mg (d) 0.5 mg

5. Two masses m_1 and m_2 are attached to an inextensible string passing over a massless and frictionless pulley. Mass m_1 slides on an inclined plane whereas mass m_2 hangs freely as shown in figure below. The acceleration of m_1 down the plane would be



(a) $\frac{m_1-m_2}{m_1+m_2}g$ (b) $\frac{m_1\sin\alpha+m_2}{m_1+m_2}g$ (c) $\frac{m_2-m_1\sin\alpha}{m_1+m_2}g$ (d) $\frac{m_1\sin\alpha-m_2}{m_1+m_2}g$

6. Kirchoff's current law is valid for
(a) DC circuit only (b) AC circuit only
(c) Both DC and AC circuits (d) Circuits having active elements only

7. If $\alpha = 0.98$, $I_{CO} = 6\ \mu A$ and $I_B = 100\ \mu A$ for a transistor based amplifier, then value of I_C is about
(a) 2.3 mA (b) 3.1 mA (c) 4.6 mA (d) 5.2 mA

8. The threshold voltage V_T is negative for
(a) an n-channel enhancement MOSFET (b) an n-channel depletion MOSFET
(c) a p-channel depletion MOSFET (d) all active unipolar devices

9. The 2's complement of the binary number 1101100 in BCD is
(a) 12 (b) 13 (c) 14 (d) 15

10. A master-slave flip-flop has the characteristic that
(a) change in the input at 'Master' is immediately reflected in the output of 'Slave'.
(b) input states of both the 'Master' and 'Slave' are affected at the same time.
(c) change in the output of "Slave" follows the change in output of 'Master'.
(d) output states of both the 'Master' and 'Slave' are affected at the same time.

11. Which of the following statements is NOT correct ?
(a) Acousatic branch of diatomic linear chain is similar to the monoatomic case
(b) Both group velocity and phase velocity are equal to the velocity of sound in the long wavelength limit
(c) Under the low wavelength limit, the lattice acts as a low pass filter
(d) Acoustic and optical modes in diatomic lattice cancel each other at the boundary of first Brillouin zone

12. According to Dulong-Petit's law, the specific heat of a solid
(a) is proportional to the temperature (b) does not depend on temperature
(c) depends on square of temperature (d) is inversely proportional to temperature

13. In the X-ray diffraction pattern of a sodium metal, which has a bcc structure, the missing reflection planes will be
(a) 101 (b) 011 (c) 020 (c) 100

14. For a paramagnetic material, the energy difference between spin magnetic dipole parallel and anti-parallel to an external field H is (μB is the Bohr magnetron)
(a) $\mu_0 H / 4\pi$ (b) $\mu_B H$ (c) $2\mu_B\mu_0 H$ (d) $\mu_B\mu_0 H$

15. The Hall coefficient of a Si wafer was found to be $-7.35\times10^{-5}\ m^3C^{-1}$ in the temperature range from100 to 400 K. The type of charge carrier and the approximate value of carrier density respectively are
(a) n-type; $8.5\times10^{22}\ m^{-3}$ (b) p-type; $8.5\times10^{22}\ m^{-3}$
(c) n-type; $4.2\times10^{22}\ m^{-3}$ (d) p-type; $4.2\times10^{22}\ m^{-3}$

16. Consider oxygen gas at 300K having the mass of its molecule as 5.31×10^{-26} kg. The root mean square speed of its molecules, is about
(a) 284 m/s (b) 248 m/s (c) 348 m/s (d) 484 m/s

17. One mole of a monoatomic perfect gas initially at temperature 0°C expands from volume V_0 to $2V_0$ at constant pressure. The specific heat at constant volume of the gas is 20.8 $Jmol^{-1}K^{-1}$. The amount of heat absorbed is nearly
(a) 1179 J (b) 1779 J (c) 1979 J (d) 7972 J

18. When 100 g ice at 0°C melts, the change in entropy in cal/K is about (Take latent heat of fusion (melting) as 80 cal/g.)
(a) zero (b) 0.34 (c) 29.3 (d) 39.2

19. N distinguishable particles are distributed among three states having energies 0, k_BT and $2k_BT$ respectively. If the total equilibrium energy of the system is 151.23 k_BT, the number of particles of the system is about

(a) 152 (b) 264 (c) 356 (d) 635

20. The power per unit area emitted by a surface of a blackbody (in Wm^{-2}) at temperature 230 K is about

(a) 112.67 (b)128.67 (c) 158.67 (d) 178.67

21. A Van der Waals gas is passed through a porous plug. Let $\alpha = \frac{1}{V}\left[\frac{\partial V}{\partial T}\right]_P$ be the volume coefficient and T is the temperature. The temperature of the gas will decrease when

(a) $\alpha T = 0$ (b) $\alpha T > 1$ (c) $\alpha T = 1$ (d) $\alpha T < 1$

22. Light from a point source located at the origin gets reflected parallel to the *x*-axis from a large concave mirror. For a constant, α, the equation describing the shape of the mirror on the *x*-*y* plane is

(a) $y^2 = \alpha x + \alpha^2$ (b) $y^2 = 2\alpha x + \alpha^2$ (c) $x^2 = \alpha y + \alpha^2$ (d) $x^2 = 2\alpha y + \alpha^2$

23. The dispersion relation for a wave is given by $\omega^2 = pk + qk^3$, where ω is the angular frequency, *k* is the wave number, *p* and *q* are constants. The wave number for which both the group and phase velocities are same is

(a) $\sqrt{\frac{p}{q}}$ (b) $\sqrt{\frac{2p}{q}}$ (c) $\sqrt{\frac{p}{2q}}$ (d) $\frac{1}{2}\sqrt{\frac{2p}{q}}$

24. A thin film of oil of thickness *t* and refractive index n_0 is covering a pool of water of refractive index n_w. A ray of light of wavelength λ is incident normally on the oil surface. The condition for constructive interference of the reflected light is (*m* has integer values)

(a) $2tn_w = m\lambda$ (b) $2tn_0 = m\lambda$

(c) $2tn_0 = \left(m + \frac{1}{2}\right)\lambda$ (d) $2tn_w = \left(m + \frac{1}{2}\right)\lambda$

25. A Newton's ring experiment uses a glass lens having radius of curvature 1.0 m. The apparatus is illuminated separately by light having two different wavelengths. Suppose that one of the wavelengths is 550 nm. The 6th bright ring of the 550 nm fringe system coincides with the 5th bright ring of the other. The value of second wavelength is about

(a) 450 nm (b) 672 nm (c) 733 nm (d) 563 nm

26. The position of a particle along the x-axis as a function of time is given by $x(t) = 2\cos^2\left(\frac{\omega_1 t}{2}\right)\sin(\omega_2 t)$. We can write $x(t)$ as the superposition of n independent harmonic motions. The value of *n* is

(a) 2 (b) 3 (c) 4 (d) 5

27. Two coherent monochromatic light beams of intensities I and 4I are superimposed. The maximum and minimum possible internsities in the resulting beam are

(a) 3I and I (b) 5I and 3I (c) 7I and 5I (d) 9I and I

28. A beam of light polarized in the *x*-direction is travelling in the *z*-direction. It passes through a polarizer and reaches an analyzer. The polarization axis of the analyzer can only be rotated in the *x*-*y* plane. It is found that the intensity is 3 times smaller when the polarization axis of the analyzer is in the y direction as compare to that in the *x*-direction. The angle between the polarization axis of the polarizer and the x-axis is

(a) 30º (b) 45º (c) 60º (d) 90º

29. Consider a parallel plate capacitor with square plates of dimensions $L \times L$ each. The plates have a charge Q and are separated by a distance Δx. The plate with the positive charge has a small hole in the middle through which an electron of mass m and charge $-e$ is shot through. The minimum speed, V that the electron must have to reach the negative plate is

(a) $V = \sqrt{\frac{2Qe\Delta x}{m\varepsilon_0 L^2}}$ (b) $V = \sqrt{\frac{Qe\Delta x}{m\varepsilon_0 L^2}}$ (c) $V = \left(\frac{-Qe\Delta x}{m\varepsilon_0 L^2}\right)^2$ (d) $V = \frac{Q^2 e\Delta x}{m\varepsilon_0 L^2}$

30. Two events take place at the same place in a lab frame but occur with a time difference of 3 seconds. The same events occur with a time difference of 5 seconds in a rocket frame. The relative speed of rocket and the laboratory is

(a) 0.5c (b) 0.8c
(c) 0.6c (d) cannot be determined from this data

31. A spaceship approaches a planet with a speed 0.6c. At some point it fires a projectile with a speed 0.4c towards the planet. The speed of the projectile, as seen by an observer on the planet would be approximately

(a) 0.76c (b) 0.80c (c) 0.99c (d) 0.40c

32. The frequency of an LC oscillator is ω_0. The plates of the parallel plate capacitor are pulled apart to twice the original distance, and a dielectric (with dielectric constant $\kappa > 1$) is completely inserted into the capacitor. The new frequency of oscillation for the circuit is

(a) $\sqrt{\frac{2}{\kappa}}\omega_0$ (b) $\frac{2}{\kappa}\omega_0$ (c) $\sqrt{\frac{\kappa}{2}}\omega_0$ (d) $\frac{\kappa}{2}\omega_0$

33. A particle is moving at a speed of $2.6\times10^8\ ms^{-1}$ relative to the laboratory. Its lifetime as measured by an observer in the laboratory is 4.7×10^{-6} s. The lifetime of the particle in its own rest frame is about

(a) $2.3\times10^{-6}\,s$ (b) $9.4\times10^{-6}\,s$ (c) $4.7\times10^{-6}\,s$ (d) $14.4\times10^{2}\,s$

34. For a wave function defined as $\psi(x) = \left(\frac{2}{L}\right)^{1/2} \sin\left(\frac{\pi x}{L}\right)$ in the region $0 < x < L$ and $\psi(x) = 0$ outside this region, the average value of the square of the momentum $\left(p^2\right)$ is,

(a) $\frac{\hbar\pi}{L}$ (b) $\frac{h^2\pi^2}{L^2}$ (c) $\frac{\hbar^2\pi^2}{L^2}$ (d) 0

35. A sample of radioactive ^{235}Pa nucleus undergoes beta decay with a half-life $\left(t_{1/2}\right)$ of 24 minutes. If the activity of this radioactive sample is 1 Curie, its mass will be about

(a) $3.0\times10^{-8}\,gm$ (b) $8.2\times10^{-9}\,gm$ (c) $4.9\times10^{-9}\,gm$ (d) $7.5\times10^{-8}\,gm$

36. The ground state spin and parity of $^{19}F_9$ nuclei will be

(a) Proton : $J^{\pi} = \left(\frac{5}{2}\right)^{+}$ (b) Neutron : $J^{\pi} = \left(\frac{5}{2}\right)^{-}$

(c) Proton : $J^{\pi} = \left(\frac{3}{2}\right)^{+}$ (d) Neutron : $J^{\pi} = \left(\frac{3}{2}\right)^{-}$

37. The kinetic energy of the electrons emitted from the n = 3 state of the hydrogen atom, when illuminated with blue light of wavelength 450 nm, is approximately

(a) 2.76 eV (b) 4.27 eV (c) 1.51 eV (d) 1.25 eV

38. The binding energies of ^1H, ^4He and ^7Li are B_1, B_4 and B_7 respectively. The Q value of the reaction $^1H + {}^7Li \rightarrow 2\ {}^4He + Q$ is given by

(a) $2B_1 + 4B_7 - 6B_4$ (b) $B_1 + B_7 - 2B_4$ (c) $B_4 - B_1 - B_7$ (d) $B_1 + 7B_7 - 8B_4$

39. Consider the matrix

$$A = \begin{pmatrix} 2 & 2 \\ 2 & 5 \end{pmatrix}$$

If $B = 2e^A$, the determinant of B is

(a) $4e^7$ (b) $4\left(e^7 - e^4\right)$ (c) e^7 (d) $e^7 - e^4$

40. The value of the determinant $\begin{vmatrix} 2 & 5 & 3+2i \\ 9 & 2 & 5-4i \\ -20 & -9 & 3+6i \end{vmatrix}$ is

(a) 656 + 256i (b) –656–256i (c) 656 (d) –656

41. The most general solution of the differential equation $\frac{d^2y}{dx^2} + \frac{4dy}{dx} + 4y = 0$ is (here 'a' and 'b' are constants)

(a) $ae^{-2x} + be^{2x}$ (b) $ae^{-2x} + be^{-2x}$ (c) $ae^{-2x} + bxe^{-2x}$ (d) $ae^{2x} + bxe^{2x}$

42. The value of the integral $\int_1^{\infty} e^{-(x-1)^3}(x-1)^5 dx$ is

(a) $-\frac{1}{3}$ (b) $-\frac{2}{3}$ (c) $\frac{1}{3}$ (d) $\frac{2}{3}$

43. Which of the following sets of vectors constitute a basis for the plane

(i) (0, 1), (1, 1)
(ii) (1, 1), (1, –1)
(iii) (1, 0), (0, –1)

(a) all three sets of vector (b) only (iii)
(c) only (i) and (iii) (d) only (ii) and (iii)

44. The equation $a^2x^2 + y^2 = 2(x + yb)$ is the equation of a

(a) parabola (b) hyperbola (c) circle (d) ellipse

45. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to the plane with angular velocity ω. Another disc of same mass but half the radius is gently placed over it coaxially. The angular speed of the composite disc will be

(a) $\frac{3}{4}\omega$ (b) $\frac{4}{5}\omega$ (c) $\frac{5}{2}\omega$ (d) $\frac{2}{5}\omega$