DU PHD 2018

Total No. of Question: 50

Time: 2 Hours **Maximum Marks: 200**

1. There are 50 questions in the Test Paper with four responses (a), (b), (c) and (d). Of them only one is correct as the best answer to the question concerned.
2. There will be **NEGATIVE MARKING** for wrong answer. Each correct answer shall be awarded 4 marks, while one mark will be deducted for each wrong answer.
3. Multiple answering of a question will cause the answer to be rejected.

Q1. An infinite long wire carries a time independent current $I = 1$ Ampere. The wire is bent and a semi-circle detour of radius $R = 1cm$ is made with the centre at the origin. The magnitude of magnetic field at the origin is

(a) $\frac{25\mu_0}{4\pi}T$ (b) $2.5\mu_0 T$ (c) $25\ \mu_0 T$ (d) $\frac{2.5\mu_0}{4\pi}T$

Q2. In a rotational structure of electronic bands (the transition between rotational levels of the different electronic levels) having a large rotational constant of the upper electronic level than the lower one,

(a) band head appears in R-branch (b) band head appears in P-branch

(c) band head appears in Q-branch (d) no band head appears

Q3. In a bistable multivibrator, commutating capacitor are used to

(a) change the frequency of the output (b) provide a.c. coupling

(c) increase the base storage output (d) increase the speed of response

Q4. In the Geiger Muller (GM) region, when the applied voltage is increased, which of the following happens?

(a) The pulse amplitude increase but the counting rate remains nearly constant.

(b) The pulse amplitude remains nearly constant and the counting rate increases

(c) Both the pulse amplitude and the counting rate increases

(d) Both the pulse amplitude and the counting rate remain nearly constant.

Q5. In the absorption spectra of harmonic vibrating diatomic oscillator, only one spectral line is observed. It is because

(a) Separation between any two adjacent E-level is same

(b)All other lines are very weak in intensity

(c) Only one molecule is present in a particular E-level

(d) Only one transition is possible from ground E-level to higher E-level

Q6. Magnetic field required to bend a non-relativistic charge particle of energy E in an arc of radius R is

(a) inversely proportional to $\sqrt{E}$ and directly proportional to R

(b) directly proportional to E and inversely proportional to R^2

(c) directly proportional to $\sqrt{E}$ and inversely proportional to R

(d) inversely proportional to $\sqrt{E}$ and directly proportional to R^2

Q7. The number of ways in which two particles can be distributed in six states, if the particles are indistinguishable and only one particle can occupy any one state, is

(a) 31 (b) 36 (c) 21 (d) 25

Q8. Consider a $2-D$ harmonic oscillator with mass m and frequency ω. A perturbation $H' = bxy$ is applied to the system. Where x and y are the two spatial coordinates. The first order correction to the ground state energy is

(a) 0 (b) $\pm\frac{bh}{2m\omega}$ (c) $\frac{bh}{2m\omega}$ (d) $-\frac{bh}{2m\omega}$

Q9. An electron of charge $-e$ is decelerated at a constant rate from an initial velocity v_0 to rest over a distance $d\left(v_0 << c\right)$. The energy lost to radiation is given by

(a) $\frac{\mu_0 e^2 v_0^3}{6\pi cd}$

(b) $\frac{\mu_0 e^2 v_0^2}{3\pi cd}$

(c) cannot be determined from the information supplied

(d) $\frac{\mu_0 e^2 v_0^3}{12\pi cd}$

Q10. The lattice constant and saturation magnetization of BCC iron at $0\,K$ are $2.87\,\overset{0}{A}$ and $1950\ kAm^{-1}$, respectively. The net magnetic moment per iron atom in the crystal is

(a) $2.30\times10^{-23}\ Am^2$ (b) $0.67\times10^{-21}\ Am^2$

(c) $7.30\times10^{-25}\ Am^2$ (d) $1.87\times10^{-22}\ Am^2$

Q11. Consider the density matrix of a two level system given by

$$\rho=\frac{2}{3}|1\rangle\langle1|+\frac{1}{3}|2\rangle\langle2| \text{ then}$$

(a) The expectation value of the operator $O_2=\frac{h}{2}\left(|1\rangle\langle2|+|2\rangle\langle1|\right)$ is $\frac{5h}{6}$

(b) The expectation value of the operator $O_1=\frac{h}{2}\left(|1\rangle\langle1|-|2\rangle\langle2|\right)$ is $\frac{h}{6}$

(c) The system is in a pure state

(d) $\langle O_1\rangle=O_2$ where $O_1=\frac{h}{2}\left(|1\rangle\langle1|-|2\rangle\langle2|\right)$

Q12. A quantum mechanical particle of mass m and charge q is subjected to a potential of the form $V(\vec{r})=\frac{1}{2}m\omega^2\vec{r}^{\,2}$, where ω is a constant. An electric field $\vec{E}=E_0\hat{x}$ is now switched on (E_0 being a constant). What is the consequent change up to second order in E_0, in the energy of the second excited state?

(a) $\frac{q^2E_0^2}{m\hbar\omega}$ (b) $\frac{q^2E_0^2\left(x^2\right)}{(m\hbar\omega)^2}$ (c) $\frac{2q^2E_0^2}{2m\omega^2}$ (d) $\frac{q^2E_0^2}{2m\omega^2}$

Q13. For the infinite square well potential the unperturbed wave functions are

$$\psi_n^0(x)=\sqrt{\frac{2}{a}}\sin\left(\frac{n\pi}{a}x\right)$$

if the floor of the well is raised by V_0, the first order correction to the energy is

(a) $\frac{V_0}{4}$ (b) $\frac{V_0}{2}$ (c) $\frac{V_0}{3}$ (d) V_0

Q14. Lead (Pb) starts superconducting at $7.19\ K$ when the applied magnetic field is zero. When a magnetic field of 0.074 Tesla is applied at $2K$, superconductivity disappears. The critical magnetic field for lead (Pb) is

(a) $0.04\ T$ (b) $0.08\ T$ (c) $0.034\ T$ (d) $0.068\ T$

Q15. If $\hat{A}$ and $\hat{B}$ are two linear operators, then the commutator bracket $\left[\hat{A}, \hat{B}^{-1}\right]$ is equal to

(a) $\hat{A}^{-1}\left[\hat{A}, \hat{B}\right]\hat{B}^{-1}$ (b) $-\hat{A}^{-1}\left[\hat{A}, \hat{B}\right]\hat{A}^{-1}$

(c) $\hat{B}^{-1}\left[\hat{A}, \hat{B}\right]\hat{B}^{-1}$ (d) $-\hat{B}^{-1}\left[\hat{A}, \hat{B}\right]\hat{B}^{-1}$

Q16. For a simple harmonic oscillator of mass m and angular frequency ω, let $|n\rangle$ represent the n-th energy eigenstate so that $\hat{H}|n\rangle = \hbar\omega\left(n+\frac{1}{2}\right)|n\rangle$. The physical state at time $t=0$ is represented by $|\psi(0)\rangle = \frac{1}{\sqrt{3}}|2\rangle - \frac{1}{\sqrt{2}}|3\rangle - \frac{1}{\sqrt{6}}|1\rangle$. If one makes a measurement of the energy of the system at any subsequent time t, the probability of finding the energy to be $3\hbar\omega/2$:

(a) Depends on time t (b) is $\frac{1}{2}$

(c) is $\frac{1}{6}$ (d) is 0

Q17. For temperatures $10\,K$ and $20\,K$, a superconductor has the critical magnetic field as 0.15 Tesla and 0.60 Tesla, respectively. The transition temperature for this superconductor in Kelvin is

(a) 23.3 (b) 15.0 (c) 22.4 (d) 4.2

Q18. A theory has equally spaced non degenerate energy levels starting from $E_{\min} = E_o$ all the way up to $E = \infty$. The system of many such particles is at equilibrium at a temperature T. If the average energy-squared of the particles is given by $\langle E^2 \rangle = 5E_0^2$. What is T ?

(a) $T = E_0/2k_B$ (b) $T = 2E_0/k_B$ (c) $T = 3E_0/2k_B$ (d) $T = E_0/k_B$

Q19. The Hamiltonian for a spin $1/2$ particle of mass m in an external field is given by

$$\hat{H} = \frac{\vec{p}\cdot\vec{p}}{2m} + g(t)\vec{\sigma}\cdot\vec{p}$$

Where $g(t)$ is a time-dependent coupling constant and $\vec{\sigma}$ are the Pauli matrices. Which of the following statements is true?

(a) The energy and all the components of the spin angular momentum of the particle are conserved

(b) The linear momentum and all the components of the spin angular momentum of the particle are conserved

(c) The linear momentum and the magnitude of the spin angular momentum of the particle are conserved

(d) The linear momentum and the energy of the particle are conserved

Q20. A solid contains N spin-half magnetic atoms. At sufficiently high temperatures, the atoms are randomly oriented, while at sufficiently low temperatures, they are perfectly aligned. The heat capacity is given by

$$C(T) = \begin{cases} C_0\left(\frac{T}{T_0} - 1\right) & T_0 \le T \le 3T_0 \\ 0, & \text{otherwise} \end{cases}$$

Where C_0 and T_0 are constants. Determine the maximum value of C_0.

(a) $\frac{Nk_B \ln 2}{2 - \ln 3}$ (b) $\frac{Nk_B \ln 2}{2}$ (c) $\frac{2Nk_B \ln 2}{2 + \ln 3}$ (d) $\frac{Nk_B \ln 2}{\ln 3}$

Q21. Green's function corresponding to the laplacian operator

$$\nabla^2 G(\vec{r}, \vec{r}\,') = -\frac{1}{4\pi\left|(\vec{r}, \vec{r}\,')\right|}$$

The value of $\phi(\vec{0})$ corresponding to the solution of the in homogeneous differential equation

$$\nabla^2\phi = \frac{A\exp(-\beta r)}{r}$$

(Where A and β are positive numbers) is equal to,

(a) 0 (b) $\frac{A}{4\pi\beta}$ (c) $-\frac{A}{B}$ (d) $\frac{\pi\beta}{A}$

Q22. A star is pulsating isotropic ally. Its gravitational force on any body, at distances much larger than its own mean radius, is given by

$$\vec{F}(\vec{r}) = \left(\frac{-k}{r^3} + \frac{a}{r^4}\right)\vec{r}$$

where k and a are positive constants. Which of the following is true about the motion of the body?

(a) Any bounded motion is described by a recessing ellipse

(b) No bounded motion exists at all

(c) Any bounded motion is described by a pulsating ellipse.

(d) Any bounded motion is still in an elliptical path, but the parameters of the ellipse are shifted from those in the Newtonian case.

Q23. The Hamiltonian for a particle in one dimension is given by

$$H(x,p) = \frac{p^2}{2m} + \lambda px + \frac{\lambda}{2}x^2$$

Where m, λ are constants? The corresponding Lagrangian is

(a) $L = \frac{m}{2}(\dot{x})^2 - \lambda m x\dot{x} - \frac{\lambda}{2}x^2$

(b) $L = \frac{m}{2}(\dot{x} - \lambda x)^2 - \lambda m x\dot{x} - \frac{\lambda}{2}x^2$

(c) $L = \frac{m}{2}(\dot{x} - \lambda x)^2 - \frac{\lambda}{2}x^2$

(d) $L = \frac{m}{2}(\dot{x})^2 - \frac{\lambda}{2}x^2$

Q24. Consider the 2π periodic function $f(x)$ defined as

$$f(x) = \begin{cases} x(n-x), & x \in [0,\pi] \\ x(x-\pi), & x \in [-\pi, 0] \end{cases}$$

Which of the following is true?

(a) $f(x) = \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\sin(2k+1)x}{(2k+1)^3}$

(b) $f(x) = \frac{8}{\pi}\sum_{k=0}^{\infty} \frac{\sin(kx)}{k^3}$

(c) $f(x) = \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\sin kx}{k^2} + \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\cos(kx)}{k^2}$

(d) $f(x) = \frac{8}{\pi}\sum_{k=0}^{\infty} \frac{\sin[(2k+1)x]}{(2k+1)^3}$

Q25. In 3-dimensional space, a particle of mass m moves in a potential $A\cos^2\beta r$ where r the distance of the particle from the origin is, A and β are real constants. Which of the following statement are correct?

(a) The motion is periodic in r with an oscillation distance $\frac{\pi}{\beta}$

(b) The motion is periodic in r with an oscillation distance $\frac{2\pi}{\beta}$

(c) The trajectory of the particle is always confined to some plane passing through the origin

(d) The radial momentum p_r is conserved because of the periodic nature of the potential.

Q26. The $^{90}Sr \xrightarrow{\beta^-} {}^{90}Y \xrightarrow{\beta^-} {}^{90}Zr$ chain decay with a half life of 28 years and 64 hours, respectively. If $1g$ of pure ^{90}Sr is allowed to decay then the ratio $\left(\frac{N_{Sr}}{N_r}\right)$ after 1 hour is

(a) 3.56×10^4 (b) 3.56×10^5 (c) 4.56×10^4 (d) 4.56×10^5

Q27. For the electronic configuration $2p3d$, the complete spectroscopic terms in Russel-Saunders coupling scheme are

(a) $^1P, {}^1D, {}^1F, {}^1G, {}^1H, {}^3P, {}^3D, {}^3F, {}^3G, {}^3H$ (b) $^2P, {}^2D, {}^2F, {}^4P, {}^4D, {}^4F$

(c) $^2S, {}^2P, {}^2D, {}^2F, {}^4S, {}^4P, {}^4D, {}^4F$ (d) $^1P, {}^1D, {}^1F, {}^3P, {}^3D, {}^3F$

Q28. The Hamiltonian of a two-level system is given by $H=\frac{1}{2}\hbar\omega\sigma_z$. At time $t=0$ the system is in the eigenstate of σ_x having the largest eigenvalue. The expectation values $\langle\sigma_x\rangle(t), \langle\sigma_y\rangle(t)$ and $\langle\sigma_z\rangle(t)$ (where σ_i are Pauli matrices) are respectively

(a) $\sin\left(\frac{\omega t}{2}\right), 0$, and $\cos\left(\frac{\omega t}{2}\right)$ (b) $\cos\left(\frac{\omega t}{2}\right), \sin\left(\frac{\omega t}{2}\right)$ and 0

(c) $0, \cos\left(\frac{\omega t}{2}\right)$ and $\sin\left(\frac{\omega t}{2}\right)$ (d) $-\cos\left(\frac{\omega t}{2}\right), 0$ and $\sin\left(\frac{\omega t}{2}\right)$

Q29. The Lagrangian for a system is given by $L = \dot{q}_1\dot{q}_2 - \omega^2 q_1 q_2$ where ω is a constant and $q_1 = \frac{dq_1}{dt}.L$ is invariant under the following transformations $q_1 = e^{\alpha} q_1$ and $q_2 = e^{-\alpha} q_2, \alpha$ is a constant. The conserved quantity corresponding to this symmetry transformation is

(a) $q_1\dot{q}_1 + q_2\dot{q}_2$
(b) $q_1\dot{q}_2 - q_2\dot{q}_1$
(c) $q_1\dot{q}_2 + q_2\dot{q}_1$
(d) $q_1\dot{q}_1 - q_2\dot{q}_2$

Q30. An integral is defined to be $I = \int_0^{\infty} \frac{\sin x}{x} dx$. Then I is equal to :

(a) $-\frac{\pi}{\cos\sqrt{2}}$
(b) $\frac{\pi}{2}$
(c) $\frac{2}{\pi}$
(d) $-\frac{\cos\sqrt{2}}{\pi}$

Q31. In the given a stable multivibrator, the frequency of the square wave generated is

(a) 32.4 kHz
(b) 3.5 kHz
(c) 324 Hz
(d) 3.5 Hz

Q32. A point mass m is attached through a mass less incompressible rod of length ℓ, to a fixed point. The mass is allowed to have any motion consistent with the above. If θ be the instantaneous angle of the rod with the vertical, which of the following is necessarily true? (Here $k \geq 0$ is an arbitrary constant)

(a) $\ddot{\theta} + \frac{g}{\ell}\sin\theta = 0$
(b) $\ddot{\theta} + \frac{k\sin\theta}{\cos^2\theta} + \frac{g}{\ell}\sin\theta = 0$
(c) $\ddot{\theta} + \frac{g}{\ell}\theta = 0$
(d) $\ddot{\theta} - \frac{k\cos\theta}{\sin^3\theta}\frac{g}{\ell}\sin\theta = 0$

Q33. Neutrons are captured by ^{10}B to form ^{11}B which breaks into an alpha particles and the Li nucleus. Then the kinetic energy of the ^{7}Li and the Q value of the reaction are

Given $M\left({}^{10}B\right) = 10.01611\ amu; M\left({}^{1}n\right) = 1.008987\ amu$;

$M\left({}^{7}Li\right) = 7.01822\ amu; M\left({}^{4}He\right) = 4.003879\ amu$)

(a) 1.01 MeV and 2.59 MeV
(b) 1.78 MeV and 2.79 MeV
(c) 1.01 MeV and 2.79 MeV
(d) 1.78 MeV and 2.59 MeV

Q34. An ultra fast laser produces a sequence of pulses with a repetition time of T. The pulse is a wave packet of energy E and a central wavelength of λ. The laser beam Hits a mirror at an angle θ to the normal and is reflected. The average force on the mirror is

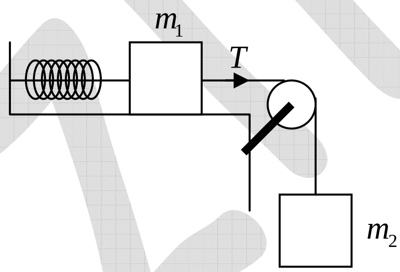
(a) None of these (b) $\frac{2E\cos\theta}{cT}$

(c) $\frac{E\cos\theta}{cT}$ (d) $\frac{E\cos 2\theta}{cT}$

Q35. The canonical partition function for a system of N non interacting particles is given by $\frac{1}{N!}(\alpha kT)^{3N}$, where α and k are constants. The internal energy of the system is (large N)

(a) $3NkT$ (b) $\frac{3}{2}NkT$ (c) $2NkT$ (d) $6NkT$

Q36. The acceleration of the system given in the figure, where k is the spring constant and x is the displacement relative to the relaxed length of the spring, is



(a) $\frac{-kx+m_1g}{m_1+m_2}$ (b) $\frac{kx-m_2g}{m_1+m_2}$

(c) $\frac{-kx+m_2g}{m_1+m_2}$ (d) $\frac{kx-m_1g}{m_1+m_2}$

Q37. A system, in three dimensions, is described by the Lagrangian

$$L=\frac{m}{2}\left(\dot{x}^2+\dot{y}^2+\dot{z}^2\right)\dot{x}\sin(t)-\frac{k}{x^2+y^2}+x\cos(t)$$

Where k is constant. Of energy (E), linear momentum $(\vec{p})$ and angular momentum $(\vec{j})$. Which are conserved?

(a) p_z alone (b) E, p_z and J_z alone

(c) $E, \vec{p}, \vec{J}$ (d) $\vec{p}$ alone

Q38. For a simple harmonic oscillator of mass m and angular frequency ω, if $|n\rangle$ represents the n-th energy eigenstate, then the expectation value $\langle n|\hat{p}^2|n\rangle$ is equal to

(a) $mhn\omega$ (b) $mh\omega\left(n+\frac{1}{2}\right)$

(c) $mh\omega(2n+1)$ (d) 0

Q39. A feedback amplifier has an open loop gain of -100. If 4% of the output is fed back in a degenerative loop, the closed loop gain of the amplifier would be:

(a) $+25$ (b) $+33$ (c) -30 (d) -20

Q40. In the first order X-ray (wavelength of $0.3\,nm$) diffraction measurement of a crystal having a body centred cubic structure of lattice constant $0.4\ nm$, the diffracted beam for the (111) plane will emerge at an angle

(a) 20.25^0 (b) 40.5^0 (c) 81.0^0 (d) 10.12^0

Q41. A particle of mass m moves in a screened coulomb potential given as $(\vec{r})=-k\frac{e^{-\alpha r}}{r}$ where k and a are positive constants. The condition for the existence of circular orbits for this motion would be given by

(a) $\dot{\theta}=\sqrt{\frac{k}{m}(1+a\,r_0)r_0^{-1/2}e^{-ar_0/2}}$ (b) $\dot{\theta}=\sqrt{\frac{k}{m}(1+a\,r_0)r_0^{-3/2}e^{-ar_0/2}}$

(c) $\dot{\theta}=\sqrt{\frac{k}{m}(1-a\,r_0)r_0^{-3/2}e^{-ar_0/2}}$ (d) $\dot{\theta}=\sqrt{\frac{k}{m}(1-a\,r_0)r_0^{-1/2}e^{-ar_0/2}}$

Q42. In a field effect transistor(FET), when the drain current changes from $1mA$ to $1.9mA$ with a change in gate –to source voltage of $0.3V$, the Tran conductance is

(a) $3.0\,A/V$ (b) $3.0\,mA/V$ (c) $9.6\,A/V$ (d) $9.6\,mA/V$

Q43. The solution to the non-linear differential equation

$$\frac{df}{dx}+\alpha f^2=0$$

with boundary condition $f(0)=1$ ad α a constant is given by,

(a) $\cos\alpha x$ (b) $\frac{\sin\alpha x}{\alpha x}$ (c) $(\alpha x+1)^{-1}$ (d) $(\alpha x+1)^{-2}$

Q44. The Hamiltonian for a particle of mass m in one dimension is given by

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2 + \lambda|x|$$

where ω and λ are real positive constants. For a small value of λ, the ground state energy to the leading order in λ is

(a) $E_0 = \frac{1}{2}\hbar\omega + 2\lambda\sqrt{\frac{\hbar}{m\pi\omega}}$ (b) $E_0 = \frac{1}{2}\hbar\omega + \frac{3\lambda}{2}\sqrt{\frac{\hbar}{m\pi\omega}}$

(c) $E_0 = \frac{1}{2}\hbar\omega + \lambda\sqrt{\frac{\hbar}{m\pi\omega}}$ (d) $E_0 = \frac{1}{2}\hbar\omega + \frac{\lambda}{2}\sqrt{\frac{\hbar}{m\pi\omega}}$

Q45. Three 32×32 matrics A_i are known to obey the commutation rule

$$\left[A_i, A_j\right] = i \in_{ijk} A_k$$

The matrix A_i has the following eigen values:

± 2 (twice each), ± 1 (7 times each) and 0 (14 times)

If $A^2 = A_1^2 + A_2^2 + A_3^2$. How often does A^2 have the eigenvalue 0?

(a) 14 times (b) The information is incomplete

(c) 7 times (d) Never

Q46. For a Geiger Muller (GM) counter experiment, which of the following statement is true?

(a) GM counter cannot detect gamma-rays

(b) GM counter can measure the energy of the both the beta and gamma-rays

(c) GM counter cannot discriminate between beta rays and gamma rays

(d) Efficiency of the GM counter for gamma rays is more than that for beta rays.

Q47. For the molecules of an ideal gas the ratio of most probable speed to average speed to root mean square velocity is given by

(a) $\sqrt{2} : \sqrt{\frac{\pi}{8}} : \sqrt{3}$ (b) $\sqrt{2} : \sqrt{\frac{\pi}{8}} : \sqrt{2}$ (c) $\sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$ (d) $\sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$

Q48. Consider an atom in a flame in optical wavelengths. What would the typical Doppler broadening of a line be?

(a) 10^{12} Hz (b) 10^{3} Hz (c) 10^{6} Hz (d) 10^{9} Hz

Q49. Which of the following equation is not gauge invariant?

(a) $\nabla^2 \cdot \vec{B} = \frac{1}{c^2}\frac{\partial^2 \vec{B}}{\partial t^2} = 0$ (b) $\vec{\nabla} \cdot \vec{E} = 0$

(c) $\vec{\nabla}^2 \vec{E} = \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2} = 0$ (d) $\vec{\nabla}\vec{A} = \frac{1}{c}\frac{\partial \phi}{\partial t} = 0$

Q50. A small mass m with a charge q is attached to a spring constant k and allowed to oscillate with amplitude A. Assuming that the amplitude of the oscillations and the speed of the mass is small, the time averaged power radiated by the system is

(a) $\frac{\mu_0 q^2 A^2 k^2}{6\pi cm}$ (b) $\frac{1}{\sqrt{\epsilon_0 \mu_0^3}}\frac{q^2 A^2 k^2}{m^2}$ (c) $\frac{\mu_0 q^2 A^2 k^2}{12\pi cm^2}$ (d) $\sqrt{\epsilon_0 \mu_0^3}\frac{qA^2 k^2}{12\pi m^2}$