Phys. 2306 Exam 3 F09 Instructions

November 3, 2009
INSTRUCTIONS AND FORMULAS EXAM 3 F09 PHYS. 2306

This is a closed book exam. No books, notes, computers or other paper may be brought into the exam. All cell phones must be shut off. The honor system is in effect. No one should seek from or give any aid to another and should report instances of cheating if observed.

You may use a calculator and these instruction sheets on this exam. Bring a sufficient quantity of number 2 pencils to work with. These instruction sheets have been sent to you before the exam and you will find a hard copy stapled to the exam questions. Thus do not bring another copy of these instructions to the exam. Use bathrooms before the exam because you can’t return after leaving the exam room.

Make sure your family name, given name, VT id number are on the answer sheet. Be sure to indicate the form, A-E, that you are using or you’ll get an incorrect mark that is usually detrimental. You must also put this information on the instruction and question sheets. Needless to say, your exam will only be graded, if your answer sheet, question sheets and instruction sheets are returned. This protects the integrity of the makeup exam.

The exam will last 2 hours. For scratch paper you may use the backside of the instruction and question sheets. If you mark your answer sheet incorrectly, we can look at the scratch sheets to correct your grade. The relevant formulas from chapters 15, 16, and 21-29 of the text are below. If you think any others would be of help, you can memorize or understand how to derive them. If your calculation method is correct and you keep sufficient significant digits, your answer should not differ from a correct choice by more than 3%.

\[
\begin{align*}
velocity \quad v^2 & = (\lambda f)^2 \quad \text{wavelength} \quad \text{frequency} \\
\text{medium} - \text{items} \quad v^2 & = F/\mu = B/\rho = Y/\rho \\
\frac{\partial^2 y(x,t)}{\partial x^2} - \frac{1}{v^2} \frac{\partial^2 y(x,t)}{\partial t^2} & = 0 \quad \text{1d} - \text{wave} \quad \text{eq} \quad \text{displacement} \\
y(x,t) & = A \cos 2\pi(x/\lambda \pm ft) \quad \text{sinusoidal} \quad \text{wave} \quad (4) \\
P_{av} & = 0.5\sqrt{\mu F(2\pi f A)^2} \quad \text{power} \\
I_1/I_2 & = (r_2/r_1)^2 \quad \text{intensity} \quad \text{distance} \quad \text{relation}(6)
\end{align*}
\]
\[ I = \frac{p_{\text{max}}^2}{(2\rho v)} \text{ sound - wave} \quad (7) \]

\[ p_{\text{max}} = BA2\pi/\lambda \text{ pressure - sound - wave} \quad (8) \]

\[ \beta = (10 \text{ dB}) \log(1/10^{-12}) \quad (9) \]

\[ y = y_1 + y_2 \text{ superposition} \quad (10) \]

\[ \text{standing - wave} \quad f_n = (1,2,3\ldots)v/(2L) \text{ stringends - fixed} \quad (11) \]

\[ = (1,2,3\ldots)v/(2L) \text{ open - pipe} \quad (12) \]

\[ = (1,3,5\ldots)v/(4L) \text{ stopped - pipe} \quad (13) \]

\[ f_{\text{beat}} = f_1 - f_2 \quad (14) \]

\[ f_L = f_S\frac{v + v_L}{v + v_S} \text{ Doppler} \quad (15) \]

\[ \sin \alpha = \frac{v}{v_S} \text{ shock - wave} \quad (16) \]

Constructive, destructive interference when waves arrive in phase, \( \lambda/2 \) out of phase.

\[ \mathbf{F}_1 = q_1\mathbf{E}(r_1) \quad (17) \]

\[ \mathbf{E}(\mathbf{r}) = \sum_j \mathbf{E}_j(\mathbf{r}) \text{ superposition - from - charges - } q_j \quad (18) \]

\[ \mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0} \sum_j q_j \frac{\mathbf{r} - \mathbf{r}_j}{|\mathbf{r} - \mathbf{r}_j|^3} \text{ charges - } q_j \text{ - at } \mathbf{r}_j \quad (19) \]

\[ = \frac{1}{4\pi\varepsilon_0} \int dq' \frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|^3} \text{ continuous - } q' \text{ - density} \quad (20) \]

\[ dq' = dr'\lambda(\mathbf{r}') = dA'\sigma(\mathbf{r}') = dV'\rho(\mathbf{r}') \quad (21) \]

\[ \mathbf{E}_{\text{axial,ring}}(x) = \frac{1}{4\pi\varepsilon_0} (\lambda 2\pi R) x(x^2 + R^2)^{-3/2}\mathbf{i} \text{ } \lambda - \text{ uniform} \quad (22) \]

\[ \mathbf{E}_{\text{line}}(x) = \frac{1}{4\pi\varepsilon_0} (L\lambda) \frac{1}{x(x^2 + (L/2)^2)^{1/2}}\mathbf{i} \quad (23) \]

\[ \mathbf{E}_{\text{axial,disk}}(x) = \frac{\sigma}{2\varepsilon_0} [1 - \frac{x}{\sqrt{x^2 + R^2}}]\mathbf{i} \text{ } \sigma - \text{ uniform} \quad (24) \]

\[ \mathbf{T}_{\text{dipole}} = \mathbf{p} \times \mathbf{E} \text{ torque - in - } \mathbf{E} \quad (25) \]

\[ U_{\text{dipole}} = -\mathbf{p} \cdot \mathbf{E} \text{ potential - energy - in - } \mathbf{E} \quad (26) \]

\[ \int \mathbf{E} \cdot n dA = Q_{\text{en}}/\varepsilon_0 \text{ Gauss - Law - vacuum} \quad (27) \]
Electric field magnitudes for various geometries and charges using $R$ for radius of sphere or cylinder:

- $E_1$ distance $r$ from point charge $q$.
- $E_2$ distance $r$ from conducting sphere with charge $q$, $r>R$.
- $E_3$ distance $r$ from conducting sphere with charge $q$, $r<R$.
- $E_4$ distance $r$ from insulating sphere with charge $q$ spread uniformly, $r>R$.
- $E_5$ distance $r$ from insulating sphere with charge $q$ spread uniformly, $r<R$.
- $E_6$ distance $r$ from infinite, conducting cylinder with charge/length $\lambda$, $r>R$.
- $E_7$ distance $r$ from infinite, conducting cylinder with charge/length $\lambda$, $r<R$.
- $E_8$ anywhere from an infinite plane of uniform charge/area $\sigma$

\[
E_1 = \frac{q}{4\pi\epsilon_0 r^2} \tag{28}
\]
\[
E_2 = E_1 \tag{29}
\]
\[
E_3 = 0 \tag{30}
\]
\[
E_4 = E_1 \tag{31}
\]
\[
E_5 = \frac{qr}{4\pi\epsilon_0 R^2} \tag{32}
\]
\[
E_6 = \frac{\lambda}{2\pi\epsilon_0 r} \tag{33}
\]
\[
E_7 = 0 \tag{34}
\]
\[
E_8 = \frac{\sigma}{2\epsilon_0} \tag{35}
\]

The work done by the electric force on a point charge $Q$ in moving $Q$ from $a$ to $b$ is independent of the path and so can be expressed in terms of a potential energy $U$.

\[
W_{a\rightarrow b} = \int_a^b QE \cdot dr = U_a - U_b \tag{36}
\]
\[
V = \frac{U}{Q} \text{ potential} \tag{37}
\]
\[
\Delta V = (U_a - U_b)/Q = \int_a^b E \cdot dr \tag{38}
\]
\[
V_a = \frac{1}{4\pi\epsilon_0} \sum_i \frac{q_i}{|r_a - r_i|} \text{ point - charges} \tag{39}
\]
\[
= \frac{1}{4\pi\epsilon_0} \int \frac{dq}{|r_a - r|} \text{ charge - distribution} \tag{40}
\]
\[ E_{x,y,z} = \frac{\partial V}{\partial x, y, z} \quad (41) \]
\[ C = KC_0 = Q/\Delta V = \frac{K\epsilon_0 A}{d} \parallel \text{plates} \quad (42) \]
\[ \frac{1}{C_{\text{series}}} = \sum_i \frac{1}{C_i} \quad (43) \]
\[ C_{\text{parallel}} = \sum_i C_i \quad (44) \]
\[ U = \frac{C\Delta V^2}{2} = \frac{Q^2}{2C} \quad (45) \]
\[ U/vol = \frac{K\epsilon_0 E^2}{2} \quad (46) \]
\[ \int KE \cdot ndA = Q_{\text{free,en}}/\epsilon_0 \quad \text{Gauss – law – dielectric} \quad (47) \]

\[ I = \frac{dQ}{dT} = n|q|v_d A \quad \text{current} \quad (48) \]
\[ J = nq\nu \quad \text{current – density} \quad (49) \]
\[ J = E/\rho \quad \text{Ohm’s law – } \rho \text{ – constant} \quad (50) \]
\[ R = V/I = \rho L/A \quad (51) \]
\[ V_{ab} = E – Ir \quad \text{power – source – with – internal – } r \quad (52) \]
\[ P = I\Delta V = I^2R = (\Delta V)^2/R \quad \text{power} \quad (53) \]
\[ R_{eq} = \sum_i R_i \quad \text{series} \quad (54) \]
\[ \frac{1}{R_{eq}} = \sum_i \frac{1}{R_i} \quad \text{parallel} \quad (55) \]
\[ \sum I = 0 \quad \text{Kirchoff – junction – rule} \quad (56) \]
\[ \sum \Delta V = 0 \quad \text{Kirchoff – loop – rule} \quad (57) \]
\[ q = Q_f(1 - \exp -\frac{t}{RC}) \quad \text{RC – circuit – charging} \quad (58) \]
\[ q = Q_0 \exp -\frac{t}{RC} \quad \text{RC – circuit – discharging} \quad (59) \]
\[ F = qv \times B \quad \text{magnetic – force – on – a – charged – particle} \quad (60) \]
\[ F = iL \times B \quad \text{magnetic – force – on – a – current – carrier} \quad (61) \]
\[ \Phi_B = \int \mathbf{B} \cdot \mathbf{n} \, dA \quad \text{normal to surface} \quad (62) \]
\[ \vec{\mu} = I \mathbf{a} \quad I - clockwise \quad \mathbf{n} - into \quad \text{paper} \quad (63) \]
\[ \vec{\tau} = \vec{\mu} \times \mathbf{B} \quad (64) \]
\[ U = -\vec{\mu} \cdot \mathbf{B} \quad (65) \]
\[ \mathbf{B}(\mathbf{r}) = \frac{\mu_0 q \mathbf{v} \times (\mathbf{r} - \mathbf{r}')}{4\pi |\mathbf{r} - \mathbf{r}'|^3} \quad \mathbf{r}' - is - q's \quad \text{position} \quad (66) \]
\[ d\mathbf{B}(\mathbf{r}) = \frac{\mu_0 I d\mathbf{L}' \times (\mathbf{r} - \mathbf{r}')}{4\pi |\mathbf{r} - \mathbf{r}'|^3} \quad \mathbf{r}' - is - d\mathbf{L}'s \quad \text{position} \quad (67) \]
\[ B(r) = \frac{\mu_0 I}{2\pi r} \quad \text{outside} - \text{long} - \text{wire} - \text{cylinder} \quad (68) \]
\[ B(x) = \frac{\mu_0 I a^2}{2(x^2 + a^2)^{3/2}} \quad \text{axis} - \text{of} - \text{loop} \quad (69) \]
\[ B(r) = \frac{\mu_0 I r}{2\pi R^2} \quad \text{inside} - \text{long} - \text{cylinder} \quad (70) \]
\[ B(r) = \mu_0 n I \quad \text{inside} - \text{solenoid} - \text{near} - \text{center} - 0 - \text{outside} \quad (71) \]
\[ B(r) = \frac{\mu_0 N I}{2\pi r} \quad \text{inside} - \text{toroid} - 0 - \text{outside} \quad (72) \]
\[ \text{EMF} = -\frac{d\Phi_B}{dt} \quad \text{acts} - to - oppose - what - causes - it \quad (73) \]
\[ = \int \mathbf{E} \cdot d\mathbf{L} \quad (74) \]
\[ d\mathbf{L} = \text{clockwise} \quad \mathbf{n} - \text{for} - \Phi_B - \text{into} - \text{paper} \quad (75) \]
\[ I_D = \epsilon \frac{d\Phi_E}{dt} \quad \text{displacement} - \text{current} \quad (76) \]
\[ \oint \mathbf{B} \cdot \mathbf{n} dA = 0, \quad \text{closed} - \text{surface} - \text{bounding} - a - \text{volume} \quad (77) \]
\[ \int \mathbf{B} \cdot d\mathbf{L} = \mu (I + I_D) \quad (78) \]