

Exam 1

Exam 1 will be held in-class on Thursday, 22 October, 2026 from 12:30 PM to 1:45 PM in room PHYS-1410, the regular lecture hall.

Please spread out in the lecture hall. Obtain permission from the proctor before leaving the room.

This is a closed-book exam. No calculators or electronic devices of any kind can be used in the exam.

A formula sheet will be provided on the first page of the exam. A preview of page 1 of the exam is given below, If you feel that anything is missing from this list of equations, please let me know ASAP!

How to prepare for the exam? The homework is your first line of defense - review the homeworks and the provided solutions here on ELMS. Make sure that you understand everything, and if not, please ask questions. Problem solving, like that done in the recitation, is the key skill to help you learn the material, and to prepare for the exam.

All students with accommodations are requested to take the exam at ADS.

SIGNATURE _____

Neatly written Name: _____

Student ID # _____

Exam 1
PHYS 313 Electricity and Magnetism I
 22 October, 2026

Obtain permission from the proctor before leaving the room.

No calculators or electronic devices of any kind can be used in the exam.

Point totals are given in brackets for each part of the question.

If you run out of room, continue writing on the back of the same page. If you do so, make a note on the front part of the page!

Note: You must solve the problem following the instructions given in the problem. Correct answers alone will not receive full credit.

Partial Credit:

→ Show Your Work! Answers written with no explanation will not receive full credit

→ You may receive credit for describing the method you would use to solve a problem, even if you missed an earlier part.

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$$\int_a^b \vec{\nabla} Q \cdot d\vec{l} = Q(\vec{b}) - Q(\vec{a}) \quad \int_V \vec{\nabla} \cdot \vec{v} \, d\tau = \oint_S \vec{v} \cdot d\vec{a} \quad \int_S (\vec{\nabla} \times \vec{v}) \cdot d\vec{a} = \oint_{\text{perimeter}} \vec{v} \cdot d\vec{l} \quad \vec{\nabla} \cdot \left(\frac{\hat{r}}{r^2} \right) = 4\pi \delta^3(\vec{r})$$

$$\vec{\nabla} t = \frac{\partial t}{\partial x} \hat{x} + \frac{\partial t}{\partial y} \hat{y} + \frac{\partial t}{\partial z} \hat{z} \quad d\tau = dx dy dz \quad \vec{\nabla} t = \frac{\partial t}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial t}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial t}{\partial \phi} \hat{\phi} \quad d\tau = r^2 dr \sin \theta d\theta d\phi$$

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{|\vec{z}|^2} \hat{z} \quad \vec{z} = \vec{r} - \vec{r}' \quad \vec{F}_{\text{tot}} = \frac{Q}{4\pi\epsilon_0} \sum_{i=1}^N \frac{q_i \hat{z}_i}{|\vec{z}_i|^2} \quad \vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \sum_{i=1}^N \frac{q_i \hat{z}_i}{|\vec{z}_i|^2}$$

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{dq \hat{z}}{|\vec{z}|^2} \quad dq \rightarrow \begin{cases} \lambda dl \\ \sigma da \\ \rho d\tau \end{cases} \quad \oint_S \vec{E} \cdot d\vec{a} = \frac{Q_{\text{enc}}}{\epsilon_0} \quad \vec{\nabla} \cdot \vec{E} = \rho/\epsilon_0 \quad \vec{\nabla} \times \vec{E} = 0 \quad \vec{E} = -\vec{\nabla} V$$

$$V(\vec{r}) = -\int_{\text{Ref pt.}}^{\vec{r}} \vec{E} \cdot d\vec{l} \quad V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{dq}{|\vec{z}|} \quad V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\vec{r}') d\tau'}{|\vec{z}|} \quad V(\vec{b}) - V(\vec{a}) = -\int_a^b \vec{E} \cdot d\vec{l}$$

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \int_{\text{Volume}} \frac{\rho(\vec{r}') d\tau'}{|\vec{z}|} \quad \text{or} \quad \frac{1}{4\pi\epsilon_0} \int_S \frac{\sigma(\vec{r}') da'}{|\vec{z}|} \quad \text{or} \quad \frac{1}{4\pi\epsilon_0} \int_{\text{Line}} \frac{\lambda(\vec{r}') dl'}{|\vec{z}|} \quad \nabla^2 V = -\rho/\epsilon_0$$

$$W = \frac{1}{2} \sum_{i=1}^N q_i V(\vec{r}_i) \quad W = \frac{1}{2} \int \rho V \, d\tau \quad W = \frac{\epsilon_0}{2} \int_{\text{All space}} E^2 \, d\tau$$

$$\vec{E} = \vec{E}_{\text{ext}} + \vec{E}_{\text{int}} = 0 \text{ inside a metal in EE.} \quad \vec{E} = \frac{\sigma}{\epsilon_0} \hat{n} \quad \sigma = \epsilon_0 \vec{E} \cdot \hat{n} = -\epsilon_0 \frac{\partial V}{\partial n} \quad C = Q/V \quad \nabla^2 V = 0$$

$$V(\vec{r}) = \frac{1}{4\pi R^2} \oint_{\text{sphere}} V \, da \quad \text{Cartesian: } V(x, y, z) = X(x) Y(y) Z(z) \quad \text{Cylindrical: } V(s, \phi, z) =$$

$$S(s) \Phi(\phi) Z(z) \quad \text{Spherical: } V(r, \theta, \phi) = R(r) \Theta(\theta) \Phi(\phi) \quad \nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2}$$

$$\nabla^2 f = \frac{1}{s} \frac{\partial}{\partial s} \left(s \frac{\partial f}{\partial s} \right) + \frac{1}{s^2} \frac{\partial^2 f}{\partial \phi^2} + \frac{\partial^2 f}{\partial z^2} \quad \nabla^2 f = \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial f}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial f}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 f}{\partial \phi^2}$$

$$V(r, \theta) = \sum_{\ell=0}^{\infty} \left(A_{\ell} r^{\ell} + \frac{B_{\ell}}{r^{\ell+1}} \right) P_{\ell}(\cos \theta) \quad \int_0^{\pi} P_{\ell}(\cos \theta) P_{\ell'}(\cos \theta) \sin \theta \, d\theta = \delta_{\ell\ell'} \frac{2}{2\ell+1}$$

$$\frac{1}{z} = \frac{1}{r} \sum_{\ell=0}^{\infty} \left(\frac{r'}{r} \right)^{\ell} P_{\ell}(\cos \alpha) \quad \left(\frac{r'}{r} \ll 1 \text{ assumed} \right) \quad V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \sum_{\ell=0}^{\infty} \frac{1}{r^{\ell+1}} \int_V \rho(\vec{r}') (r')^{\ell} P_{\ell}(\cos \alpha) \, d\tau'$$

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \left\{ \frac{1}{r} \int \rho(\vec{r}') \, d\tau' + \frac{1}{r^2} \int r' \cos \alpha \rho(\vec{r}') \, d\tau' + \frac{1}{r^3} \int (r')^2 \frac{1}{2} (3 \cos^2 \alpha - 1) \rho(\vec{r}') \, d\tau' + \frac{1}{r^4} \int (r')^3 \frac{1}{2} (5 \cos^3 \alpha - 3 \cos \alpha) \rho(\vec{r}') \, d\tau' + \dots \right\}$$

$$V_{\text{monopole}}(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad V_{\text{dipole}}(r) = \frac{1}{4\pi\epsilon_0} \frac{\vec{p} \cdot \hat{r}}{r^2} \quad \vec{p} = \sum_{i=1}^N q_i \vec{r}_i$$

$$\vec{p} \equiv \int \vec{r}' \rho(\vec{r}') \, d\tau' \quad V_{\text{quad}}(r) = \frac{1}{4\pi\epsilon_0} \frac{1}{r^3} \int (r')^2 \frac{1}{2} (3 \cos^2 \alpha - 1) \rho(\vec{r}') \, d\tau' \quad \vec{E}_{\text{dipole}} = \frac{p}{4\pi\epsilon_0 r^3} (2 \cos \theta \hat{r} + \sin \theta \hat{\theta})$$

Problem	Credit	Max. Credit
1		25
2		25
3		25
4		25
TOTAL		100