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| **Name:** | |
| **Student ID:** | |

# Example Examination

## Phys331: Electromagnetic Theory I

**2025/09/29**

*Please carefully read below before proceeding!*

I acknowledge by taking this examination that I am aware of all academic honesty conducts that govern this course and how they also apply for this examination. I therefore accept that I will not engage in any form of academic dishonesty including but not limited to cheating or plagiarism. I waive any right to a future claim as to have not been informed in these matters because I have read the syllabus along with the academic integrity information presented therein.

I also understand and agree with the following conditions:

**(1)** all calculations are to be conducted in the notations and conventions of the formulae sheets provided during the exam unless explicitly stated otherwise in the question;

**(2)** I take *full responsibility* for any ambiguity in my selections in "multiple choice questions";

**(3)** incorrect selections will receive $-1/7$ of the question's points;

**(4)** I am expected to provide *step-by-step explanation of how I solved the question* and am expected to do so *only within the answer boxes* provided with the questions: the explanation is supposed to be succinct, well-articulated, and correct both scientifically and mathematically;

**(5)** no partial credit is awarded for the explanations provided in the answer boxes;

**(6)** some questions of some students will be randomly selected for inspection: *a question (if selected for inspection) might be awarded negative points* if its explanation is incorrect or insufficient to get the correct answer, even if the correct option is selected;

**(7)** any page which does not contain *both my name and student id* will not be graded;

**(8)** any extra sheet that I may use are for my own calculations and will not be graded.

**Signature:** _____

This exam has a total of 3 questions, some of which may be for bonus points. You can obtain a maximum grade of 105+0 from this examination.

| Question: | 1 | 2 | 3 | Total |
|---|---|---|---|---|
| Points: | 7 | 21 | 77 | 105 |

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**Question:** 1: Concept of Units (A simple case study) . . . . . *(7 points)*

In cosmology, the kinematics are handled using a different unit-system than SI; indeed, although *meter* and *second* are the standard units for most of the engineering and applied physics, they are too small for cosmological scales so instead we might prefer *lightyear* and *gigayear* which we can take to be $\mathrm{ly} = 10^{16}\,\mathrm{m}$ $\mathrm{Gyr} = 3\times10^{16}\,\mathrm{s}$. Then, if absolute value of the angular momentum per units mass for the galaxy Andromeda is approximated as $|\boldsymbol{j}| = 2\times10^{26}\,\mathrm{m}^2\ \mathrm{s}^{-1}$ in the SI units, which option below would be the correct expression for it?

☐ $|\boldsymbol{j}| = 6^{-1}\times10^{16}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = 6\times10^{16}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = 6\times10^{10}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = \frac{2}{3}\times10^{10}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$

☐ $|\boldsymbol{j}| = \frac{2}{3}\times10^{-10}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = 6\times10^{-10}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = 6\times10^{-16}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$ ☐ $|\boldsymbol{j}| = 6^{-1}\times10^{-16}\,\mathrm{ly}^2\,\mathrm{Gyr}^{-1}$

***Please provide below the step-by-step explanation of how you obtained your result(s) for question 1:***

**Question:** 2: Concept of Units (A complicated case study) . . . . . *(21 points)*

On his 1881 paper *"On the physical units of nature"*, G. Johnstone Stoney argues the utility of choosing fundamental units in terms of constants of nature, hence creating a unit system which is named after him. In this so-called *Stoney natural units*, we trade the SI units $\mathrm{A}$, $\mathrm{m}$, $\mathrm{kg}$, $\mathrm{s}$ for the constants of nature $c, e, G, \epsilon_0$ which we will take to be defined as

$$\begin{aligned} \text{(speed of light) } c &= 3\times10^{8}\,\mathrm{m\ s^{-2}} \\ \text{(charge of proton) } e &= 2\times10^{-19}\,\mathrm{A\ s} \\ \text{(gravitational constant) } G &= 7\times10^{-11}\,\mathrm{m^3\ kg^{-1}\ s^{-2}} \\ \text{(vacuum permittivity) } \epsilon_0 &= 9\times10^{-12}\,\mathrm{A^2\ m^{-3}\ kg^{-1}\ s^{4}} \end{aligned} \tag{1}$$

in this question.

Answer the questions below based on these definitions, along with the facts

$$\sqrt{630} \approx 25 \quad , \quad \begin{pmatrix} 0 & 1 & 0 & -2 \\ 1 & 0 & 0 & 1 \\ 0 & 3 & -1 & -2 \\ 2 & -3 & -1 & 4 \end{pmatrix}^{-1} = \frac{1}{8}\begin{pmatrix} 6 & 6 & -1 & 1 \\ -4 & 4 & 2 & -2 \\ 0 & 8 & -4 & -4 \\ -6 & 2 & 1 & -1 \end{pmatrix} \tag{2}$$

(a) **(7 points)** Consider Alice, whose mass is measured to be "$80\,\mathrm{A}^0\ \mathrm{kg}^1\ \mathrm{s}^0\ \mathrm{m}^0$" in SI units. In Stoney natural units, her mass would be "$X c^{a_1} e^{a_2} G^{a_3} \epsilon_0^{a_4}$" for some exponents $a_i$. What is $X$?

☐ $10^3$ ☐ $10^4$ ☐ $10^5$ ☐ $10^6$

☐ $10^7$ ☐ $10^8$ ☐ $10^9$ ☐ $10^{10}$

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(b) **(7 points)** Consider Alice again: which of below would be her mass in Stoney natural units?

☐ $X c^0 e^1 G^{-1/2} \epsilon_0^{-1/2}$ ☐ $X c^0 e^1 G^{1/2} \epsilon_0^{-1/2}$ ☐ $X c^0 e^1 G^{-1/2} \epsilon_0^{1/2}$ ☐ $X c^0 e^1 G^{1/2} \epsilon_0^{1/2}$
☐ $X c^0 e^{-1/2} G^1 \epsilon_0^{-1/2}$ ☐ $X c^0 e^{-1/2} G^1 \epsilon_0^{1/2}$ ☐ $X c^0 e^{1/2} G^1 \epsilon_0^{-1/2}$ ☐ $X c^0 e^{1/2} G^1 \epsilon_0^{1/2}$

(c) **(7 points)** Now assume that Alice has done some work, say 10 Joules in SI units. What would be this in Stoney natural units for some $Y \in \mathbb{R}$?

☐ $Y c^{1/2} e^{3/4} G^{1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{1/2} e^{3/2} G^{1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{1/2} e^{3/4} G^{-1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{1/2} e^{3/2} G^{-1/4} \epsilon_0^{-3/4}$
☐ $Y c^{-1/2} e^{3/4} G^{1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{-1/2} e^{3/2} G^{1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{-1/2} e^{3/4} G^{-1/4} \epsilon_0^{-3/4}$ ☐ $Y c^{-1/2} e^{3/2} G^{-1/4} \epsilon_0^{-3/4}$

***Please provide below the step-by-step explanation of how you obtained your result(s) for question 1:***

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**Question:** Some other questions . . . . . *(77 points)*

⋮

In the actual exam, there would be four to six questions, each with possibly two to three parts, totaling to 105 for the total score. It may be 6 total parts of 7 points each and 6 total parts of 10.5 points each ($6 \times 7 + 6 \times 10.5 = 105$), 3 total parts of 7 points each and 8 total parts of 10.5 points each ($3 \times 7 + 8 \times 10.5 = 105$), or any other appropriate point distribution.

As there will be four examinations in total with the same format (3 midterms and 1 final), your final letter grade will be based on $52 \pm 8$ gradable question parts in total.

« « « Congratulations, you have made it to the end! » » »