

Physics 326 Midterm Exam #2 Spring 2015

Monday Apr 20, 12:30 pm – 1:50 pm

This is a closed book exam. No use of calculators or any other electronic devices is allowed. Work the problems only in your answer booklets only. The exam questions will *not* be collected at the end, so

anything you write on these question pages will NOT be graded

You have **80 minutes** to work the problems.

At the beginning of the exam:

- 1) Write your **name** and **netid** on your answer booklet(s).
- 2) Turn your **cell phone off**.
- 3) Put away all calculators, phones, computers, notes, and books.

During the exam:

- 1) **Show your work** and/or reasoning. **Answers with no work or explanation get no points.** But ...
- 2) **Don't write long essays** explaining your reasoning. We only need to see enough work to confirm that you understand what you're doing and are **not just guessing**. Also a good **annotated sketch** is often the best explanation of all!
- 3) **All question parts on this exam are independent**: you can get full points on any part even if your answers to all the other parts are incorrect. Therefore you should **attempt all the question parts!** If you get stuck, move on to the next one and come back later. The worst thing you can do is stall on one question and not get to others whose solution may be very simple.
- 4) Partial credit will be given for incorrect answers if the work is understandable and some of it is correct. IMPORTANT: If you think you've made a mistake but can't find it, **explain what you think is wrong** → you may well get partial credit for noticing your error!
- 5) It is fine to leave answers as **radicals or irreducible fractions** (e.g. $10\sqrt{3}$ or $5/7$).

Remember: There are many Math Tables provided → do Use Them!
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When you're done with the exam:

Turn in only your **answer booklet**. (Keep the exam questions).

Academic Integrity:

The giving of assistance to or receiving of assistance from another person, or the use of unauthorized materials during University Examinations can be grounds for disciplinary action, up to and including expulsion from the University.

Please be aware that prior to or during an examination, the instructional staff may wish to rearrange the student seating. Such action does not mean that anyone is suspected of inappropriate behavior.

You must derive any expression that is not on the formula sheet.

You may of course use from memory any formulae from a previous class, e.g. 325, 225, 211.

Problem 1 : A Binary Star System

Star A of mass m and Star B of mass $2m$ orbit around each other. A space station (of negligible mass) is parked at the center-of-mass position of this two-star system. The distance between the stars has a minimum value of d and a maximum value of $3d$. Express all answers in terms of m , d , and/or physical constants.

- Calculate the system's period (i.e. the time the system takes to go from some state back to the same state).
- Calculate the minimum distance between the space station and either of the stars, and indicate which star (A, B, or both) reaches this distance of closest approach.

Problem 2 : Death Star!

The Death Star exerts a force $\vec{F}(r) = -(Km/r^3)\hat{r}$ on any object of mass m that wanders by, where K is a positive constant. A group of unpowered spaceships starts far away from the Death Star. Each ship has the same mass m and initial velocity \vec{v}_0 . (The ships are initially moving in parallel paths, but are spread out in position). They ships eventually drift into the Death's Star's attractive force field ... oh no! The Death Star is so massive compared with the ships that it can be treated as fixed.

- Calculate the capture cross-section for this scattering problem in terms of the given values K , m , v_0 and/or physical constants. (i.e. Calculate the total cross section for the Death Star to pull in an unpowered ship and prevent it from escaping back to infinity).
- One particular ship has angular momentum $L = \sqrt{25Km^2/21}$. Calculate enough to sketch the path of this ship. (You just need the correct shape of the path, so don't waste time calculating the values of any particular distances.)

Problem 3 : α Scattering from Silicon

An α particle is fired from an accelerator with an initial kinetic energy of 5 MeV, and heads toward a fixed target made of silicon (Si). The repulsive electric force between an α and a Si nucleus is $F = kq_\alpha q_{\text{Si}}/r^2$ where $kq_\alpha q_{\text{Si}} = 40 \text{ MeV fm}$. After the α scatters from a Si nucleus, it emerges at a scattering angle of 60° .

- Calculate the distance of closest approach between the α particle and the Si nucleus in units of fm. (Ignore the small radii of these particles.) Your answer should be a number (e.g. 9, $1/27$, $2\pi\sqrt{3}$ fm).
- The α particle is detected by a small, square photographic plate of size $(0.1 \text{ m}) \times (0.1 \text{ m})$. How many meters away from the target should this detector be placed so that it covers a solid angle of $1/4 \times 10^{-2} \text{ sr}$?