HW#8—Phys402—Fall 2018
Due Wenesday Nov. 7, 10am, at the beginning of class outside PSC 3151.

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1. Read https://en.wikipedia.org/wiki/Alpha_decay

2. GS 9.18 (*tunneling in the Stark effect*) Read this problem, but don't do it.

3. GS 9.3 (*tunneling through square barrier*) *Note*: "To which it should reduce" should really be "To which it should reduce, up to a factor that is independent of the width a"

4. GS 9.4 (*nuclear lifetimes* You can get data from the Live Chart of the Nuclides linked on the course webpage at the upper right. Add part (b): The result you will obtain here differs from the observed lifetimes by a few orders of magnitude. It seems to me that the main culprit of this is probably the oversimplification of the potential we used, and the choice of a particular value of r_1 which may not properly take into account the range of the nuclear potential. If we model this effect simply by a change of the effective value of the nuclear radius r_1, by roughly what percent must r_1 be changed in order to bring your result into agreement with the observed lifetimes?

5. GS 9.5 (*Zener tunneling)*

6. GS 9.6 (*bouncing ball, exact*) Modify parts (c) & (d): Instead of the 100 gram mass, and the electron, do these for a neutron only (see footnote 14). [For the electron, the average height turns out to be 1.37 mm! But I can't think of a surface that an electron would interact with weakly enough for that interaction not to dominate the gravitational effect.] *Note*: For parts (b) and (c), a web version of that book is now available: https://dlmf.nist.gov/ A super cool and useful resource!

7. GS 9.7 (*bouncing ball, WKB*) Modify part (b): do this for the neutron only. Replace part (c) by the following: It can (easily) be shown, using the WKB approximation, that in a general potential the spacing between adjacent energy levels approaches $2\pi\hbar/T$, where $T = \oint dx/v$ is the period of the corresponding classical motion (the period being computed using the *group* velocity). (i) For the linear potential in this problem, calculate $E_{n+1} - E_n$ and compare it to $2\pi\hbar/T_n$. What is their relative difference, as a function of n? How large must n be for the relative difference to be 10%? 1%? [This result shows that a "correspondence principle" between quantum and classical mechanics holds at large n: the frequencies of photons radiated in transitions between nearby levels become equal to multiples of the classical frequency of the orbit.]