Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, August, 2015, 14:00–17:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.

   (a) All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.

   (b) For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.

   (c) Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.

   (d) All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.

   (e) Each problem is worth 10 points.

   (f) Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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D1. **(Stewart)**

Useful information:

$^{99}Tc_{43}$, with 99 nucleons and 43 protons,
mass = 98.9062547 amu (atomic mass units).
1 amu =931.494061 MeV/c^2.

electron mass = 0.0005446623 amu

^{99}Tc decays by beta (electron) decay.

(a) **[2 points]** What is beta decay? Describe the process and the particles involved.

(b) **[2 points]** When ^{99}Tc decays by beta decay, how many neutrons, protons and electrons does the decay product X have?
$^{99}\text{Tc} \rightarrow X+$ beta + electron anti-neutrino ($\sim$massless) + energy

(c) **[6 points]** X, as a neutral atom, has mass = 98.905939 amu. How much energy, in units of MeV, does the beta carry away?

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DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

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D2. **(Matcheva)**

A pointlike particle is moving in a two-dimensional plane. The distance $r(t)$ from the particle to the origin O, described by polar coordinates in that plane, is given by

$$r(t) = R[1 + \sin \omega t],$$

for constants R and ω and the polar angle $\phi(t)$ with respect to the fixed x-axis is given by

$$\phi(t) = \omega t.$$

(a) **[2 points]** Compute the velocity vector of the object as a function of time.

(b) **[1 point]** For which time t is the velocity completely radial, and for which is it completely tangential?

(c) **[2 points]** Compute the acceleration vector of the object as a function of time.

(d) **[1 point]** When is the acceleration of the object perpendicular to its velocity?

(e) **[2 points]** What is the work done by the force $\vec{F}$ from $t = 0$ to t'?

(f) **[1 point]** What is the power exerted by the force at any given time t?

(g) **[1 point]** Sketch the trajectory of the object.

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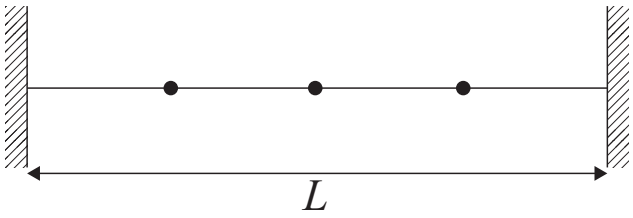
D3. **(Detweiler)** Three point masses, each having mass $M/3$, are attached to a massless string of length L at positions $\frac{1}{4}L$, $\frac{1}{2}L$, and $\frac{3}{4}L$, *i.e.*, they are equidistant from each other and from the ends of the string. The string is held at a constant tension T and clamped at both ends. Now assume that the masses are allowed to oscillate in one of the directions orthogonal to the string and with such small amplitudes that the tension remains approximately constant.



(a) **[6 points]** Find all the angular frequencies for the normal modes of this system in terms of $\omega_0^2 = T/ML$.

(b) **[4 points]** Compare the first three angular frequencies found in (a) to the first three angular frequencies of a string of mass M and length L, held under constant tension T and clamped at both ends. Express you answer in terms of $\omega_0^2 = T/ML$.