10 Nov, 2020 **Ph 136a** E.S. Phinney

**Applications of Classical Physics**

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## Problem Set 6

Due **before 1:00pm** Wednesday 18 Nov, 2020

**Readings:** Readings for this week are to complete Chapter 6 and read section 7.2 of Thorne & Blandford *Modern Classical Physics*, hereafter called TBMCP. You may skip the Track 2 material in Chapter 6 (Sec 6.5, 6.9.2, 6.9.3, though they are interesting and worth at least skimming).

**Non-Collaboration Problem** There is no non-collaboration problem this week.

**Submitting your homework** Please upload your completed homework solutions as a `pdf` file to Canvas. If that fails to work, you may instead email the file to the TA, `twang3@caltech.edu`, with the subject line `ph136 homework 6`. Note that Caltech email will reject attachment sizes larger than 10Mbyte, so be conscious of scanning parameters!

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**Homework Problems: (51 points total)**

1. Do ONE of the following two problems (whichever is more interesting to you):

   a) **TBMCP Problem 6.13 (15 points: 5+5+5)** *Allan Variance of Clocks* This is particularly important for tracking of interplanetary spacecraft, and for detection of gravitational waves from supermassive black hole binaries using pulsar timing, both of which push the precision of atomic clocks on long timescales.

   b) **TBMCP Problem 6.5 (15 points: 4+2+4+3+2)** *Proof of Doob's Theorem*

2. **TBMCP Problem 6.7 (12 points: 4+4+4))** *Cosmological Density Fluctuations*

3. **TBMCP Problem 6.12 (12 points: 2+4+2+2+2)** *Wiener's Optimal Filter* The Wiener filter is used in every aspect of your cellphone: the cellular radio, wifi and GPS and even its camera software (for image processing/deblurring), as well as in radar (matching the weak reflected signal pattern) and in LIGO data analysis!

4. **TBMCP Problem 6.17 (12 points: 3+3+3+3)** *Detectability of a Sinusoidal Force that Acts on an Oscillator with Thermal Noise* Early attempts to detect the tiny sinusoidal forces exerted on matter by gravitational waves used aluminum bars at room temperature (Joseph Weber, 1965), and later aluminum bars and niobium, silicon and quartz crystals all at cryogenic temperatures. These were direct applications of this problem. For a review and history through 2010, see https://arxiv.org/abs/1009.1138.