Physics 22 Problem Set 1

Harry Nelson

due Monday, April 9, In Class

Course Info: The instructor is Harry Nelson, the TA is Joel Varley. A web page for the course will be set up at http://hep.ucsb.edu/courses/ph22.

We meet MWF 1:00-1:50pm in 1640 Broida. There are **two sections**, attendance at **both** is mandatory. Joel Varley's section will take place Wednesday 12:00-12:50pm in 1802 Psychology, and Harry Nelson's will take place Friday 2:00-2:50pm in 2129 Girvetz. Harry Nelson's office hours will follow section until 5:00pm on Friday, either in 2129 Girvetz (if possible) or in the PSC.

The text for the course is 'An Introduction to Mechanics' by Kleppner and Kolenkow. (K&K). This is a hard textbook, but rewarding. Our plan is to cover material from Chapters 6, 7, and 9-14. I hope to start material on fluids and statistical mechanics at the end of the quarter; I will hand out material from other textbooks at that time.

Working problems is crucial to the understanding of physics. Expect to spend at least 12 hours a week outside of class studying and working problems.

Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Derive symbolic answers, and then plug in numbers after a symbolic answer is available.

These problems pertain to the first three lectures, and the corresponding reading is pp. 232-247 of K&K.

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1. This is a problem about computing torque in a variety of ways. The position in the $x-y$ plane, $\mathbf{r}$, where a force, $\mathbf{F}$ acts is:

$$\mathbf{r} = 4\hat{\boldsymbol{\imath}} + 3\hat{\boldsymbol{\jmath}} \quad \text{meter}$$

and the force $\mathbf{F}$ is

$$\mathbf{F} = -12\hat{\boldsymbol{\imath}} + 5\hat{\boldsymbol{\jmath}} \quad \text{Newton.}$$

   (a) Numerically evaluate the torque vector $\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$ using the determinant method. Numerically evaluate $|\boldsymbol{\tau}|$.

   (b) Make a diagram showing $\mathbf{r}$ and $\mathbf{F}$ on a careful $x-y$ plot. Put the tail of $\mathbf{F}$ on the tip of $\mathbf{r}$, like in the figure in the bottom left of page 238 of your text. Indicate on your diagram $\mathbf{r}_\perp$ and $\mathbf{F}_\perp$.

   (c) Evaluate $\mathbf{r}_\perp$ directly using the formula based on Problem 1.11:

$$\mathbf{r}_\perp = (\hat{\mathbf{F}} \times \mathbf{r}) \times \hat{\mathbf{F}}$$

   where $\hat{\mathbf{F}}$ is the unit vector derived from $\mathbf{F}$. The quantity $\mathbf{r}_\perp$ is sometimes called the 'moment arm' of the force $\mathbf{F}$.

      i. Evaluate $\mathbf{r}_\perp \cdot \mathbf{F}$ numerically.

      ii. Evaluate $|\mathbf{r}_\perp||\mathbf{F}|$ numerically, and compare with the magnitude of $|\boldsymbol{\tau}|$ computed in part (a).

(d) Evaluate $\mathbf{F}_\perp$ directly using the formula based on Problem 1.11:

$$\mathbf{F}_\perp = (\hat{\mathbf{r}} \times \mathbf{F}) \times \hat{\mathbf{r}}$$

where $\hat{\mathbf{r}}$ is the unit vector derived from $\mathbf{r}$.

i. Evaluate $\mathbf{F}_\perp \cdot \mathbf{r}$ numerically.

ii. Evaluate $|\mathbf{F}_\perp||\mathbf{r}|$ numerically, and compare with the magnitude of $|\boldsymbol{\tau}|$ computed in part (a).

2. Halley's Comet orbits the Sun, and returns to Earth about every 75 years. On Feb. 9, 1986, it was at its distance of closest approach to the sun, which was about 0.59 Astronomical Units (AU). One Astronomical Unit is 1.5×10^{11} meters. On that day, Halley's Comet was traveling at a speed of 54 km/s. In about 2023, Halley's Comet will reach its farthest distance from the sun, about 35 AU. What will its speed be then?

3. K&K Problem 6.4.
