

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.012: Physics (Mechanics) I

Fall Term 2005

PROBLEM SET 1

Due: Friday, September 16 at 4:00pm.

Reading: Kleppner & Kolenkow, Chapter 1

Collaboration policy: You are *encouraged* to freely discuss homework problems with other 8.012 students and teaching staff. However, you must write up your solutions **completely** on your own — you **must not** copy solutions from other students. You are also forbidden from consulting solutions from previous years or from the web. *Violations of this policy will be dealt with harshly!*

0. **Collaboration and discussion.** Please give a brief statement at the top of your homework telling us the names of all the students with whom you discussed the homework problems.

1. **Vector arithmetic.** (10 points)

Consider two vectors: $\mathbf{A} = 8\hat{x} - 6\hat{y} + 4\hat{z}$ and $\mathbf{B} = 4\hat{x} - 7\hat{y} + \hat{z}$.

- (a) Calculate $|\mathbf{A}|$ and $|\mathbf{B}|$.
- (b) Calculate $\mathbf{A}\cdot\mathbf{B}$.
- (c) What is the angle between \mathbf{A} and \mathbf{B} ?
- (d) Calculate $\mathbf{A}\times\mathbf{B}$.
- (e) Calculate $\mathbf{A}\times(\mathbf{A}\times\mathbf{B})$.

2. **More vector manipulation.** (10 points)

Consider an arbitrary unit vector $\hat{\mathbf{U}} = U_x\hat{x} + U_y\hat{y} + U_z\hat{z}$. Write down the equations that need to be satisfied for the vector $\hat{\mathbf{U}}$ to be

- (a) perpendicular
- (b) parallel

to vector \mathbf{A} as defined in the previous problem. Include a condition that guarantees $\hat{\mathbf{U}}$ to have length one (i.e., unit length). How many independent parameters are needed to describe the complete set of solutions for the two cases?

3. Kleppner & Kolenkow, Problem 1.10 (10 points)

4. Kleppner & Kolenkow, Problem 1.12 (10 points)

5. Kleppner & Kolenkow, Problem 1.13 (10 points)

6. Kleppner & Kolenkow, Problem 1.16 (10 points)

7. Kleppner & Kolenkow, Problem 1.18 (10 points)

8. Kleppner & Kolenkow, Problem 1.19 (10 points)

9. Kleppner & Kolenkow, Problem 1.21 (10 points)

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10. **Two trains and a bee.** (10 points)

Consider two trains moving in opposite directions on the same track. The trains start simultaneously from two towns, A and B , separated by a distance d . Each train travels at a constant speed v towards the other train. A bee is initially located in front of the train in town A . As the train departs A , the bee travels with speed u along the track towards B . When it encounters the second train, it reverses direction until it encounters the first train, then it reverses again, etc. The bee continues flying between the two trains until it is crushed between the trains impacting each other. The purpose of this problem is to compute the total distance flown by the bee until it is crushed. You should assume that the bee is faster than the trains ($u > v$).

There are at least two good ways to solve this problem. One is to compute the distance for each flight leg and sum the resulting series. There is also another way to solve the problem with very little calculation. You are to do it both ways.

- (a) (7 points) Find an expression for the distance d_n covered by the bee after its n^{th} encounter with a train. Thus, define d_0 as the distance traveled during the first flight from town A towards the train near town B , d_1 the distance traveled by the bee during the first trip from the B train to the A train, etc. Sum the resulting series to get the final answer.
- (b) (3 points) Can you think of another way to obtain the same answer using very little calculation? Explain.