Physics 5a: Homework 1

Abhijay Bhatnagar

September 3, 2018

Assignment

There are 13 problems worth a total of 130 points, but the maximum score you can achieve is 100 points. So if you are sure of your answers, you can get away with doing as few as 9 problems; or do some extras as a cushion. Remember - the clearer your presentation is, the easier it is for us to give you points!

Solutions

Problem 1. (5pts)

K.K. 1.1

Given: $\mathbf{A} = (2\hat{i} - 3\hat{j} + 7\hat{k}), \mathbf{B} = (5\hat{i} + \hat{j} + 2\hat{k})$.

(a) $\mathbf{A} + \mathbf{B} = (7\hat{i} - 2\hat{j} + 9\hat{k})$

(b) **A - B** $= (-3\hat{i} - 4\hat{j} + 5\hat{k})$

(c)

$$\begin{aligned} \mathbf{A} \cdot \mathbf{B} &= (2\hat{i} - 3\hat{j} + 7\hat{k}) \cdot (5\hat{i} + \hat{j} + 2\hat{k}) && (1) \\ &= (2 * 5) - (3) + (7 * 2) && (2) \\ &= 21 && (3) \end{aligned}$$

(d)

$$\mathbf{A} \text{ x } \mathbf{B} = (a_2b_3 - a_3b_2)i - (a_1b_3 - a_3b_1)j + (a_1b_2 - a_2b_1)k \quad (4)$$
$$= (-3*2 - 7*1)i - (2*2 - 7*5)j + (2*1 + 15)k \quad (5)$$
$$= (-13i + 31j + 17k) \quad (6)$$

Problem 2. (5pts)

K.K. 1.8

Given: $\hat{a}, \hat{b}$ making θ, ϕ,

Prove: $\hat{a} = cos(\theta)\hat{i} + sin(\theta)\hat{j}, \hat{b} = cos(\phi)\hat{i} + sin(\phi)\hat{j}$

Problem 3. (10pts)

K.K. 1.13

Let $\mathbf{A}$ be an arbitrary vector and let $\hat{n}$ be a unit vector in some fixed direction. Show that $\mathbf{A}$ = ($\mathbf{A}$ $\hat{n}$)$\hat{n}$ + ($\hat{n}$ $\mathbf{A}$) x $\hat{n}$.

Problem 4. (10pts)

K.K. 1.14

Problem 5. (10pts)

The relation between Cartesian (x, y, z) and spherical polar (r, θ, ϕ) coordinates is:

$$x = r \sin\theta \cos\phi$$
$$y = r \sin\theta \sin\phi$$
$$z = r \cos\theta$$

Two spaceships trace out the trajectories $(r_1, \theta_1, \phi_1) = (2 + \cos(\omega_1 t), \pi/2, \omega_2 t)$, and $(r_2, \theta_2, \phi_2) = (1, \omega_3 t, 0)$, where t is "time," and $\omega_j = \sqrt{j}$ for $j = 1, 2, 3$. If you wait arbitrarily long, what is the closest distance between the two spaceships?

Hint: the answer would be quite different if the ω_j were chosen to be rational numbers.

Problem 6.