1. Determine the volume of the solid S that is obtained by rotating the region given by

 $0 \le x \le \pi$ and $0 \le y \le \sqrt{x \sin x}$

around the x-axis.

2. Determine the center and radius of the sphere given by

 $x^2 + y^2 + z^2 - 4x - 2y + 4z = 0.$

3. Determine the vector of length 10 that points in the opposite direction as (0, 3, -4).

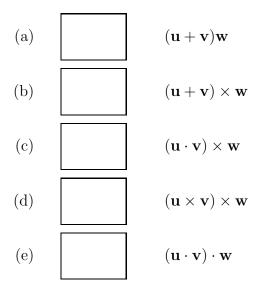
4. Determine parametric equations for the line that contains the point (-5, 1, 4) and is perpendicular to the plane 2x + 3y - 6z + 7 = 0.

5. Let $\mathbf{u}, \mathbf{v}, \mathbf{w}$ denote vectors in \mathbb{R}^3 . Which of the following expressions make sense? Write "S" if an expression makes sense, and "N" if it does not.

Recall that

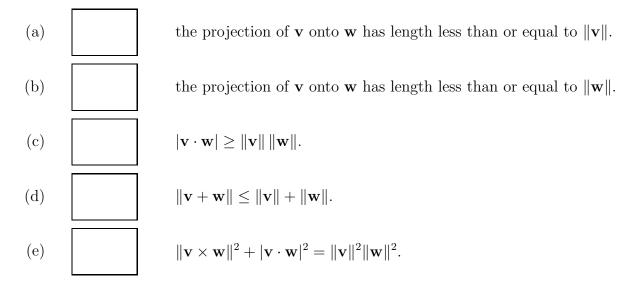
- \square "×" denotes the cross product,
- $\hfill\square$ "." denotes the dot product, and
- $\square\,$ concatenation denotes scalar multiplication.

For example, if c is a scalar and **v** is a vector, then the concatenation "c**v**" makes sense since it denotes scalar multiplication, whereas an expression like " $c + \mathbf{v}$ " does not make sense.



6. Which of the following statements are always true? Write " \mathbf{T} " for true and " \mathbf{F} " for false. Your computations will not be graded on this problem.

If \mathbf{v} and \mathbf{w} are vectors in \mathbb{R}^3 , then



7. Suppose that **a** and **b** are two vectors in \mathbb{R}^3 such that if **a** and **b** are drawn emanating from the origin, they both lie in the *xy*-plane, **a** in the third quadrant (x < 0 and y < 0) and **b** in the second quadrant (x < 0 and y > 0.)

Suppose also that we know $\|\mathbf{a}\| = 1$ and $\|\mathbf{b}\| = 4$ as well as $\mathbf{a} \cdot \mathbf{b} = 2$.

(a) Is the vector projection of \mathbf{b} onto \mathbf{a} longer than \mathbf{a} , shorter than \mathbf{a} , or the same length as \mathbf{a} ?

(b) In what direction does $\mathbf{a} \times \mathbf{b}$ point? (Give a unit vector in this direction.)

(c) Find the length of $\mathbf{a} \times \mathbf{b}$.

8. Consider the motion given by

$$\mathbf{r}(t) = (3t, \sin(4t), -\cos(4t)).$$

Compute

- (a) the velocity at time t
- (b) the speed at time t
- (c) a unit vector $\mathbf{T}(t)$ in the direction of motion at time t
- (d) the rate of change of $\mathbf{T}(t)$ with respect to time, $\mathbf{T}'(t)$
- (e) the norm (magnitude) of $\mathbf{T}'(t)$
- (f) the unit normal vector at time t
- (g) the unit binormal vector at time t

(h) the distance travelled between times t = 0 and t = 2