Instructions: Put your solutions on a separate piece(s) of paper. You may use this page as a cover sheet. Submission for credit: submit it at the START of recitation on Thursday, October 10.

Generally it is good to explain your work: an important facet of mathematics is explaining how you arrived at the answer, and not just stating the answer. (On exams you will be required to show your work.)

(1) Let \( \mathbf{u} \) and \( \mathbf{v} \) be the vectors sketched below.

(a) Sketch \( \text{proj}_\mathbf{u} \mathbf{v} \) without performing any computations.

(b) Let \( \mathbf{w} = \frac{\mathbf{u}}{|\mathbf{u}|} \). Is \( \text{proj}_\mathbf{u} \mathbf{v} \) the same as \( \text{proj}_\mathbf{w} \mathbf{v} \)?

(2) A 20-pound block rests on a plane that is inclined (height increasing from left to right) at 30° above the horizontal. Let \( \mathbf{F}_g \) be the gravitational force acting on the block. Make an illustration and work with 2-D vectors to answer the following:

(a) What is a unit vector that points down the plane (parallel to the plane)? Call this unit vector \( \mathbf{u} \).

(b) What is the force vector \( \mathbf{F}_g \)? (The magnitude of \( \mathbf{F}_g \) is 20 lbs, the weight of the block.)

(c) Consider the decomposition of \( \mathbf{F}_g \) into the sum of two component forces, one parallel to the inclined plane and one normal to the inclined plane.
   (i) Find the part of the decomposition of \( \mathbf{F}_g \) that is parallel to the inclined plane. Compute this as the orthogonal projection of \( \mathbf{F} \) onto \( \mathbf{u} \).

   (ii) Find the part of \( \mathbf{F}_g \) that is normal (aka perpendicular) to the inclined plane? Compute this as \( \mathbf{N} = \mathbf{F} - \text{proj}_\mathbf{u} \mathbf{F} \).
(3) The figure below is a trapezoid made up of 5 equilateral triangles. Find the angle between $\vec{AB}$ and $\vec{AC}$. Round your answer to the nearest tenth of a radian.

(4) Find the area of the triangle in the $xyz$-space whose vertices are at $(0,0,0)$, $(1,5,1)$ and $(-3,2,-1)$.

Hint: The area of the triangle is half the area of a certain parallelogram...

(5) Let $O$ be the origin in $\mathbb{R}^3$. Let’s find the set all of points $P(x,y,z)$ in $\mathbb{R}^3$, such that the corresponding position vector $\vec{w} = \vec{OP}$ is perpendicular to $\vec{v} = (2,-1,3)$, as the solution set of an equation.

(a) What do you know about $\vec{v} \cdot \vec{w}$?

(b) Determine an equation that $x, y, z$ must satisfy!

Remark: You’ve just found the equation of a particular plane through the origin!

(6) The magnetic force $\vec{F}_m$ on a point charge $q$ moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is calculated by the relationship $\vec{F}_m = q \vec{v} \times \vec{B}$. Suppose a particular particle with charge $q = 3.2 \times 10^{-19}$ Coulombs moves through a constant magnetic field $\vec{B} = 8 \hat{k}$ Tesla (1 Tesla = 1 Newton-second per Coulomb-meter) with constant velocity $\vec{v} = 20,000 \hat{i} - 30,000 \hat{j} + 10,000 \hat{k}$ meters per second. Find the magnetic force vector on this particle.

(7) When a constant force $\vec{F}$ applied to an object results in a displacement $\vec{d}$ the work done on the object is $W = \vec{F} \cdot \vec{d}$. Calculate the work done when a constant horizontal force of 30 N is used to push a box up a 20 m ramp which is inclined at an angle of 30°.