1 Cumulative Part

1. Compute the exact cosine of the angle between \( \langle 1, 1, 1 \rangle \) and \( \langle 2, 3, 4 \rangle \) (no calculator approximations) then compute the actual angle in degrees using your calculator (this answer will of course be approximate).
2. Find an equation for the plane parallel to \((1,1,1)\) and \((2,3,4)\) which passes through the point \((3,-1,1)\).
3. Show that \( \lim_{(x,y) \to (0,0)} \frac{xy}{x^2 + 2xy} \) does not exist. Hint: evaluate the limit as \((x, y)\) approaches \((0, 0)\) along the \(x\) axis \((y = 0)\) and then evaluate the limit as \((x, y)\) approaches \((0, 0)\) along the line \(y = x\). Say something brief to indicate why the results of these calculations show that the limit of this function of two variables at the origin does not exist.
4. For a particle whose position at time $t$ is $(t, t, t^2)$ determine the speed and the tangential and normal components of acceleration, both scalars and associated vectors, at the time $t = 2$. 
5. For the function $x^3y + 12x^2 - 8y$ find the critical point or points and classify them as local max, local min or saddle point using the second derivative test.
2 Test IV

1. 15.2 Evaluate
\[ \int_0^2 \int_x^2 xy \, dy \, dx \]

Sketch the region of integration.
2. Evaluate the integral

\[ \int_0^{\sqrt{\pi}} \int_x^{\sqrt{\pi}} \sin(x^2) \, dx \, dy \]

The region of integration is pictured.

First explain why you cannot evaluate it directly as written.

Then set up the integral with the order of the variables reversed, and evaluate it.
3. 15.4 polar coordinates Where the region \( D \) is the region \( x^2 + y^2 \leq 1, \ x \geq 0 \) (pictured) compute the integral of \((x^2 + y^2)^2\) over the region \( D \) by converting to polar coordinates and evaluating the resulting iterated integral.
4. 15.5 Determine the centroid of the triangle with corners at (-2,0), (0,1), (2,0) by setting up and evaluating appropriate integrals. Hint: one of the coordinates you can determine by symmetry (explain why). For the other you need to do some integration.
5. 16.2 Calculate the work done by the field \( \mathbf{F} = (y, -x) \) in traversing the upper half of \( x^2 + y^2 = 1 \) from \((1, 0)\) to \((-1, 0)\). Why is this field not conservative?

You may use the parameterization \( \mathbf{c}(t) = (\cos(t), \sin(t)), 0 \leq t \leq \pi \).
6. 16.3 One of the following vector fields is conservative and the other is not. Identify the one that is not, and explain why. For the one that is conservative, determine the potential function, and verify explicitly that the gradient of the potential function is the vector field.

(a) 

\[(1 + y)i + (x + 2y)j\]

(b) 

\[(1 - y)i + (x - 2y)j\]