There are 7 problems and 144 points total. The point value of each question is indicated. Read each question carefully!

1. (20 points.) Compute the following iterated integrals

   a) \( \int_0^3 \int_0^y y^2 \, dx \, dy \)

   b) \( \int_0^1 \int_{\sqrt{y}}^1 5 \sqrt{1 + x^5} \, dx \, dy \)
2. (18 points.) Let \( R = \{(x, y) : x^2 + y^2 \leq 4\pi^2\} \). Compute \( \int_{R} \sin(x^2 + y^2)\,dA \) using polar coordinates.

3. (18 points.) Find a formula for the line which passes through the point \((1,2,3)\) in the direction of the vector \((2,1,-3)\)
4. (28 points.) Find the velocity and acceleration along the following curves:

a) \( \dot{r}(t) = (3 \cos(t), 2 \sin(t), -t) \)

b) \( \ddot{r}(t) = (\cos(t^2), \sin(t^2), t^2) \)

c) \( \dddot{r}(t) = \left( \frac{e^{2t} + e^{-2t}}{2}, \sin(t), \frac{e^{2t} - e^{-2t}}{2} \right) \)

d) \( \dddot{r}(t) = \left( e^{1/2} \cos \left( \frac{\sqrt{3}}{2} t \right), e^{-t/2} \sin \left( \frac{\sqrt{3}}{2} t \right) \right) \)
5. (20 points.) Let \( R = \{(x, y) : 1 \leq xy \leq 4 \text{ and } 1 \leq xy^2 \leq 4\} \) Use the change of variables \( s = xy \) \( t = xy^2 \) to compute \( \int_R xy^2 \, dA \)
6.

a) (7 points) Sketch the vector field \( F(x, y) = (y, x) \)

b) (10 points) Check that \( r(t) = (e^t + e^{-t}, e^t - e^{-t}) \) is a flow line of the vector field \( F(x, y) = (y, x) \)

c) (3 points) Draw the flow line \( r(t) = (e^t + e^{-t}, e^t - e^{-t}) \) in the vector field \( F(x, y) = (y, x) \)
7. (20 points.) Let $W = \{(x, y, z) : x^2 + y^2 \geq 1 \text{ and } x^2 + y^2 + z^2 \leq 2 \}$ Compute $\int_W x^2 + y^2 \, dV$
**Extra credit** Do not work on any of these until you have finished the rest of the exam!

A) (4 points) Choose two curves from problem 4) and sketch them.

B) (6 points) Compute \( \int_{-\infty}^{\infty} e^{-x^2} \, dx \)