Name: ______________________________

1. Let $\mathbf{r}(t) = \langle \sin(t^2), \cos(t^2) \rangle$
   (a) Find the position, velocity and acceleration of the particle at time $t = \sqrt{\pi}/2$.
   (b) Graph the position, velocity and acceleration appropriately.
   (c) Find the speed function
   $$\frac{ds}{dt} = \|\mathbf{r}'(t)\|$$
   (d) Compute the arc length from $t = 0$ to $t = \sqrt{\pi}$.

2. Let $f(x, y) = 3xy^2 - e^{x^2+y^2-2}$. Find the tangent plane to $f(x, y)$ at the point $(1, 1)$. Use that plane to estimate $f(1.1, 0.9)$. Compare to the real value of $f(1.1, 0.9) \approx 1.653$.

3. Find and classify extremma. $f(x, y) = x^3 - 3xy + 3y^2$.

4. Minimize using La Grange multipliers. $f(x,y,z) = x^2+4y^2+z^2$ subject to $x-y+z = 6$.

5. $\iint_R 2x\,dA$ over the region defined by $y = 4 - x^2$ and the x-axis.

6. $\displaystyle\iint_R e^{x^2+y^2}\,dA$ over the region defined by the portion of the circle $x^2 + y^2 = 4$ in the second quadrant and outside of the circle $x^2 + y^2 = 1$.

7. $\displaystyle\iint_R \frac{e^{y+2x}}{y-x}\,dA$ over the region defined the lines $y=-2x+2$, $y=-2x+4$, $y=x+4$ and $y=x+6$.

Second Derivative Test

$$D(x, y) = f_{xx}(x, y)f_{yy}(x, y) - (f_{xy}(x, y))^2$$

1. $D(P) > 0$ and $f_{xx}(P) > 0$ minimum
2. $D(P) > 0$ and $f_{xx}(P) < 0$ maximum
3. $D(P) < 0$ saddle point
4. $D(P) = 0$ inconclusove