1. Find a vector that has the same direction as $\langle 2, -4, -2 \rangle$ but has length 8.

7 pts

2. Find the angle between the lines $x = 1 + t$, $y = 1 - t$, $z = 2t$ and $x = 2 - 3t$, $y = 3$, $z = 2 + t$.

7 pts

(OVER)

3. Find the equation of the normal plane to the curve $x = t$, $y = t^2$, $z = t^3$ at the point $(1, 1, 1)$.

7 pts

4. A particle starts at the origin with initial velocity $\mathbf{i} - \mathbf{j} + 3\mathbf{k}$. Its acceleration is $\mathbf{a}(t) = 6t\mathbf{i} + 12t^2\mathbf{j} - 6t\mathbf{k}$. Find its position function.

8 pts

5. Find the curvature of the curve given by $\mathbf{r}(t) = \langle \frac{1}{3}t^3, \frac{1}{2}t^2, t \rangle$ when $t = 1$.

8 pts

6. Determine and sketch the set of points at which the functions are continuous: (a) $f(x, y) = e^{2x} + \sqrt[3]{3y}$, (b) $g(x, y, z) = \sqrt{z - x^2 - y^2}$.

8 pts

(OVER)

7. Find the rate of change of $f(x, y) = e^{xy^2} - e^{2xy}$ at the point $(3, 2)$ in the direction of $\mathbf{v} = 2\mathbf{i} - \mathbf{j}$.

8 pts

8. **On a single set of axes**, sketch and label (a) some typical level curves of the function $f(x, y) = \sqrt{(x+1)^2 + y^2}$, as well as (b) the gradient vector at the origin. Show the scaling on the axes.

8 pts

9. Find the absolute maximum and minimum values of $f(x, y) = 2x^3 + y^4$ on the set $D = \{(x, y) \mid x^2 + y^2 \leq 1\}$.

8 pts

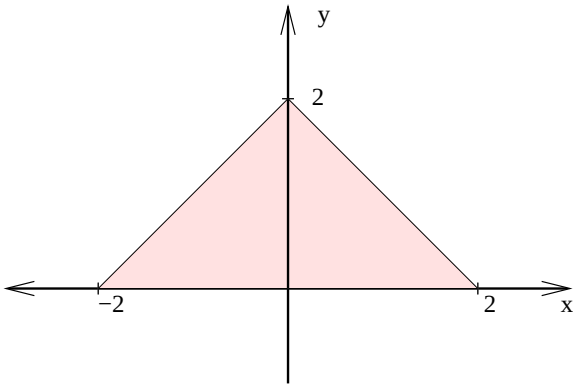
(OVER)

10. Find the **surface area** of the part of the hyperbolic paraboloid $z = y^2 - x^2$ that lies between the cylinders $x^2 + y^2 = 1$ and $x^2 + y^2 = 4$.

8 pts

11. Write $\int\int_D f(x,y)\ dA$ as an iterated integral, where D is the region shown, and f is an unspecified continuous function on D.

8 pts



12. Fully describe the solid whose volume is given by $\int_{\pi/4}^{\pi/2}\int_{\pi/2}^{\pi}\int_{1}^{3}\rho^2\sin\phi\ d\rho\ d\phi\ d\theta$. **Do not evaluate the integral.**

7 pts

(OVER)

13. **Sketch** the region of integration, and **use polar coordinates to evaluate**

$$\int_0^3 \int_{-\sqrt{9-x^2}}^{\sqrt{9-x^2}} (x^3 + xy^2)\, dy\, dx.$$

8 pts

14. **Extra credit** Find the work done by the force field $\mathbf{F}(x, y) = x\mathbf{i} + (y + 2)\mathbf{j}$ in moving an object along an arch of the cycloid $\mathbf{r}(t) = (t - \sin t)\mathbf{i} + (1 - \cos t)\mathbf{j}$, $0 \leq t \leq 2\pi$.

7 pts