(1.) $\vec{r}(t) = \langle t^2 - t,\ t^3 - 3t^2 + 3 \rangle$

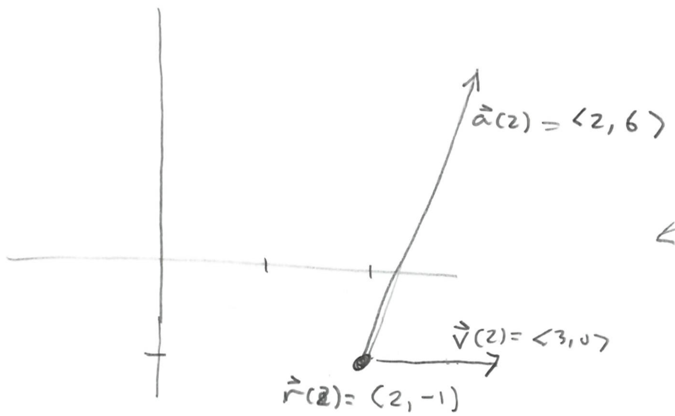
(a) Find position, velocity and acceleration at $t = 2$

$\vec{r}(t) = \langle t^2 - t,\ t^3 - 3t^2 + 3 \rangle \qquad \vec{r}(2) = \langle 4-2,\ 8 - 12 + 3 \rangle = \langle 2, -1 \rangle$

$\vec{v}(t) = \vec{r}\,'(t) = \langle 2t - 1,\ 3t^2 - 6t \rangle \qquad \vec{r}\,'(2) = \langle 4 - 1,\ 12 - 12 \rangle = \langle 3, 0 \rangle$

$\vec{a}(t) = \vec{r}\,''(t) = \langle 2,\ 6t - 6 \rangle \qquad \vec{r}\,''(2) = \langle 2,\ 12 - 6 \rangle = \langle 2, 6 \rangle$

(b)



If we graph $\vec{r}$ near the point $\vec{r}(2)$, what does it look like?

(2.) $\vec{r}(t) = \langle \sin(e^{-t}),\ \cos(e^{-t}) \rangle$

(a) Find speed.

$\vec{r}\,'(t) = \langle -e^{-t}\cos(e^{-t}),\ e^{-t}\sin(e^{-t}) \rangle$

$$\frac{ds}{dt} = \|\vec{r}\,'(t)\| = \|\langle -e^{-t}\cos(e^{-t}),\ e^{-t}\sin(e^{-t}) \rangle\|$$

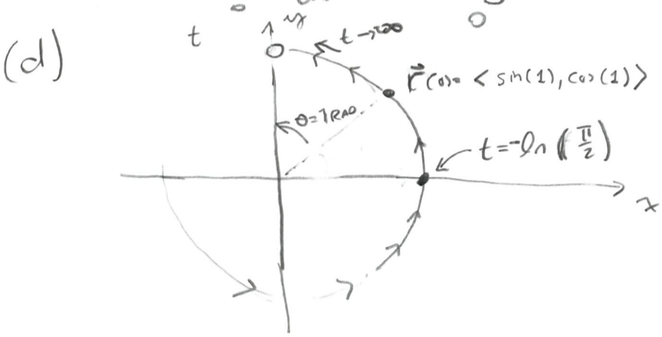
$$= \sqrt{(-e^{-t}\cos(e^{-t}))^2 + (e^{-t}\sin(e^{-t}))^2} = \dots$$

$$= e^{-t}$$

(b) $$S = \int_0^1 \frac{ds}{dt}\,dt = \int_0^1 e^{-t}\,dt = -e^{-t}\Big|_0^1 = -e^{-1} - (-e^0) = 1 - \frac{1}{e}$$

(c) $$S = \int_0^1 \frac{ds}{dt}\,dt = \int_0^\infty e^{-t}\,dt = -e^{-t}\Big|_0^\infty = \left(\lim_{t\to\infty} -e^{-t}\right) - -e^{-(0)}$$

(d)



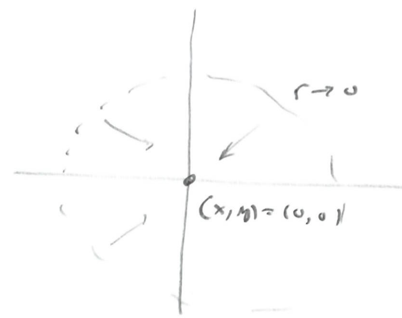
$$= \lim_{t\to\infty} \frac{-1}{e^t} + 1 = 0 + 1 = 1$$

(4.) (a) $\lim\limits_{(x,y)\to(0,0)} \dfrac{x^3+y^3}{x^2+y^2+1} = \lim \dfrac{0^3+0^3}{0^2+0^2+1} = \lim \dfrac{0}{1} = \underline{0}$

(b) $\lim\limits_{(x,y)\to(0,0)} \dfrac{1-\cos(x^2+y^2)}{x^2+y^2}$

We will show the limit exists. To do this we will use polar substitution $r^2 = x^2+y^2$, $\tan\theta = y/x$, ...

So $(x,y)\to(0,0)$ corresponds to $r\to 0$



$$= \lim_{r\to 0} \frac{1-\cos(r^2)}{r^2}$$

$$\overset{\text{L.H.}}{=} \lim_{r\to 0} \frac{0-(-1)\sin(r^2)\cdot 2r}{2r}$$

$$= \lim_{r\to 0} \sin(r^2) = \sin(0^2) = \boxed{0.}$$

(c) $\lim \dfrac{x^2+xy+y^2}{x^2+y^2}$

We will show the limit does <u>NOT</u> exist. To do this we select two paths to the origin AND show the limits along each path is different

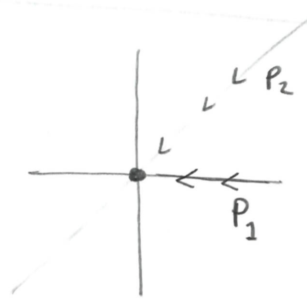
PARAMETRIZATION OF P2

$x = 0 + t = t$
$y = 0 + t = t$

$\uparrow (0,0)$ $\quad \uparrow (1,1)$ a vector

Note P_2 CONTAINS $(0,0)$ AND $(1,1)$

So $(0,0)$ is A POINT AND $\vec{V} = \langle 1-0, 1-0\rangle$ is a vector From $(1,1)$ to $(0,0)$



FIND LIMIT ALONG P2

$$\lim_{\substack{(x,y)\to(0,0)\\ P_2}} \frac{x^2+xy+y^2}{x^2+y^2} = \lim_{t\to 0} \frac{t^2+t\cdot t+t^2}{t^2+t^2} = \lim \frac{3t^2}{2t^2} = \lim \frac{3}{2} = \frac{3}{2}$$

(4c)

PARAMETRIZATION OF P1

$x = 0 + 1t = t$
$y = 0 + 0t = 0$

POINT $(0,0)$; vector is $\langle 1,0 \rangle$

P_1 contains $(0,0)$ AND $(1,0)$. So $\vec{v} = \langle 1-0, 0-0 \rangle = \langle 1,0 \rangle$ is parallel to P_1 AND $(0,0) \in P_1$

FIND LIMIT ALONG P_1

$$\lim_{\substack{(x,y)\to(0,0)\\ P_1}} \underline{\qquad} = \lim \frac{t^2 + t\cdot 0 + 0^2}{t^2+0^2} = \lim \frac{t^2}{t^2} = \lim 1 = 1$$

Since $\lim_{P_2} \frac{x^2+xy+y^2}{x^2+y^2} = \frac{3}{2} \neq 1 = \lim_{P_1} \frac{x^2+xy+y^2}{x^2+y^2}$ the limit DNE.

---

(5) $f(x,y) = x^2+y^2$ $P(0,2)$, $Q(1,2)$

(a) CONTOUR PLOT AT $z = -1, 0, 1, 2, 3, 4$

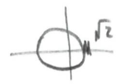
$\boxed{z=-1}$ $-1 = x^2+y^2$ NO GRAPH

$\boxed{z=0}$ $0 = x^2+y^2$

$\boxed{z=1}$ $1 = x^2+y^2$

circle radius 1

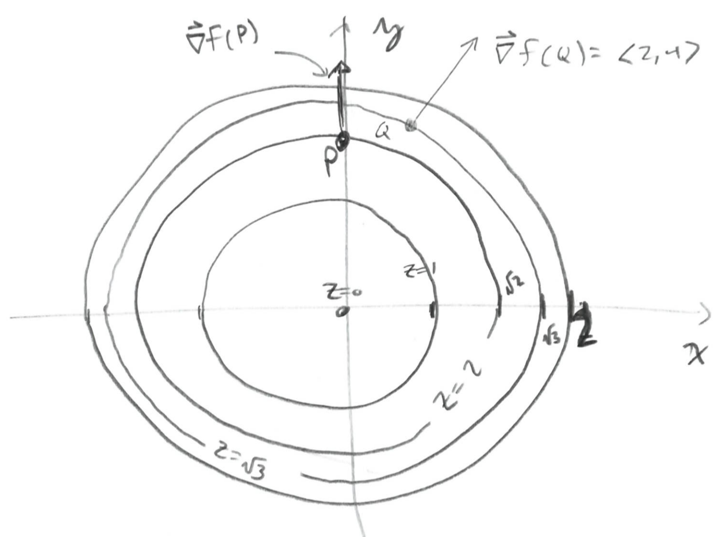
$\boxed{z=2}$ $2 = x^2+y^2$



$\boxed{z=3}$ $3 = x^2+y^2$

circle of radius $\sqrt{3}$

$\boxed{z=4}$ $4 = x^2+y^2$



(5b) COMPUTE $\vec{\nabla} f(x,y) = \left\langle \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y} \right\rangle = \langle 2x, 2y \rangle$

(5c) $\vec{\nabla} f(P) = \langle 2x, 2y \rangle (0,2) = \langle 2(0), 2(2) \rangle = \langle 0, 4 \rangle$

$\vec{\nabla} f(Q) = \langle 2x, 2y \rangle (1,2) = \langle 2(1), (2(2)) \rangle = \langle 2, 4 \rangle$

(5d) see graph on part (a)

(8.) $f(x,y) = e^{xy^2+2} - xy^3 + 2.$ $P(-2,1)$

TANGENT PLANE we need a point & a normal vector and then we can use $a(x-x_0) + b(y-y_0) + c(z-z_0) = 0$ to find the plane

POINT $(\overbrace{-2, 1}^{P}, \ )$

$f(P) = f(-2,1) = e^{(-2)(1)^2+2} - (-2)(1)^3 + 2 = e^{-2+2} + 2 + 2 = 5$

POINT $(-2, 1, 5)$

VECTOR Compute $\vec{\nabla} f(P)$ and $\vec{n} = (\vec{\nabla} f(P), -1) = \left\langle \frac{\partial f}{\partial x}(P), \frac{\partial f}{\partial y}(P), -1 \right\rangle$

$\vec{\nabla} f(x,y) = \langle f_x(x,y), f_y(x,y) \rangle = \langle y^2 \cdot e^{xy^2+2} - y^3, 2xy\, e^{xy^2+2} - 3xy^2 \rangle$

$\vec{\nabla} f(P) = \vec{\nabla} f(-2,1) = \langle (1)^2 e^{-2+2} - (1)^3, 2(-2)(1) e^{-2+2} - 3(-2)(1)^2 \rangle$

$= \langle 1 - 1, -4 + 6 \rangle = \langle 0, 2 \rangle$

So $\vec{n} = \langle 0, 2, -1 \rangle$.

So the POINT is $(-2,1,5)$ AND $\vec{n} = \langle 0, 2, -1 \rangle$. Thus

$a(x - x_0) + b(y - y_0) + c(z - z_0) = 0$

$0(x - (-2)) + 2(y - 1) + (-1)(z - 5) = 0$

$2y - 2 - z + 5 = 0$

$\boxed{z = 2y + 3}$

(8) (CONTINUED) $Z = 2y + 3$ is approximately $f(x,y)$ Near $P(-2,1)$

OR $L(x,y) = 2y + 3$

Linear Approximation (a plane)

$L(-2.1, 0.8) = 2(0.8) + 3$
$= 1.6 + 3$
$= 4.6$

$f(-2.1, 0.8) = e^{(-2.1)(0.8)^2 + 2} - (-2.1)(0.8)^3 + 2$
$= e^{0.656} + 3.0752$
$= 5.022686\ldots$

So $L(-2.1, 0.8) \approx f(-2.1, 0.8)$, an 8 % difference.
$4.6 \approx 5.022\ldots$

(9) Here use POINT $P(1,2,3, \underset{f(1,2,3)}{\uparrow})$ AND $\vec{n} = \langle f_x(P), f_y(P), f_z(P), -1 \rangle$

AND $a(x - x_0) + b(y - y_0) + c(z - z_0) + d(w - w_0) = 0$

(12.)

(a) $f(x,y) = x^2 - xy + y^3$

We will use the 2^{ND} Derivatest

(1) FIND C.P.

$f_x(x,y) = 2x - y$

$2x - y = 0$
$\downarrow$
$y = 2x$

$f_y(x,y) = 0 - x + 3y^2$

$-x + 3y^2 = 0$ ← set to zero and solve
$\downarrow$
$-x + 3y^2 = 0$
$-x + 3(2x)^2 = 0$
$-x + 12x^2 = 0$ $\quad x[-1 + 12x] = 0$

$x = 0$ | $-1 + 12x = 0$
$x = 1/12$

$y = 2x = 2(0)$ | $y = 2x = 2\left(\frac{1}{12}\right) = 1/6$

$CP_1 = (0,0)$ | $CP_2 = \left(\frac{1}{12}, \frac{1}{6}\right)$

(12) (CONTINUED)

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

$f_{xx}(x,y)=2$ $D(x,y) = (2)(6y) - (1)^2 = 12y-1$

$f_{yy}(x,y)=6y$

$f_{xy}(x,y)=1$

$\boxed{\text{Test CP1}}$ $\boxed{(0,0)}$

$D(0,0) = 12(0)-1 = -1 < 0$

saddle pt

Test $CP_2 = (\frac{1}{12}, \frac{1}{6})$

$D(\frac{1}{12}, \frac{1}{6}) = 12(\frac{1}{6})-1 = 2-1 = 1 > 0$

$f_{xx}(\frac{1}{12}, \frac{1}{6}) = 2 > 0$

$\Rightarrow$ MINIMUM

So f has a saddle pt at $(0,0)$ AND a MIN. at $(\frac{1}{12}, \frac{1}{6})$.

(12d) $f(x,y,z,w) = x^2+y^2+z^2+w^2$ S.T. $x+y+z-3w=4$

use La Grange Multipliers

LM $\vec{\nabla} f = \lambda \vec{\nabla} g$

AND $g=0$

$g(x,y,z,w) = x+y+z-3w-4$

$\nabla f = \lambda \nabla g$

$2x$	1
$2y$	1
$2z$	1
$2w$	-3

$2x = \lambda \cdot 1$

$2y = \lambda \cdot 1$

$2z = \lambda \cdot 1$

$2w = \lambda(-3)$

$x = \lambda/2$ $w = -3\lambda/2$

$y = \lambda/2$

$z = \lambda/2$

$x+y+z-3w=4$

$\frac{\lambda}{2} + \frac{\lambda}{2} + \frac{\lambda}{2} - 3(\frac{-3}{2}\lambda) = 4$

$12\lambda = 8$

$\lambda = 2/3$

$x = 2/6 = 1/3$

$y = 2/6 = 1/3$

$z = 2/6 = 1/3$

$w = -2/2 = -1$

CP $(1/3, 1/3, 1/3, -1)$

$f(CP) = (\frac{1}{3})^2 + (\frac{1}{3})^2 + (\frac{1}{3})^2 + (-1)^2 = \frac{12}{9} = 4/3$

A RANDOM POINT SATISFYING ST.

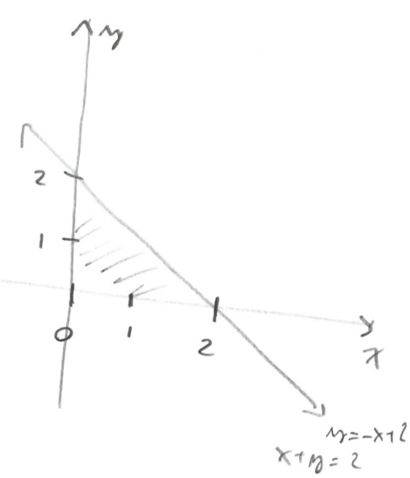
is $(1,2,1,0) \leftarrow$ check $g(1,2,1,0)=0$

$f(1,2,1,0) = 1^2+2^2+1^2+0^2 = 6$

$6 > \frac{4}{3}$ So at $(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}, -1)$ we have a minimum!

(13.) $\iint_R (x+y)\,dA$ R defined b $x+y=2$, x-axis, y-axis

graph it



$0 \le x \le 2$

$0 \le y \le -x+2$

$$\int_0^2\int_0^{-x+2}(x+y)\,dy\,dx = \int_0^2 \left[xy+\frac{1}{2}y^2\right]_{y=0}^{y=-x+2} dx$$

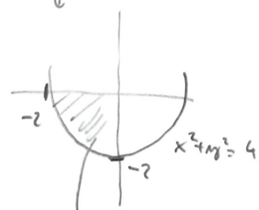
$$= \int_0^2 \Big[\underbrace{\left(x(-x+2)+\frac{1}{2}(-x+2)^2\right)}_{y=-x+2} - \underbrace{\left(x(0)+\frac{1}{2}(0)^2\right)}_{y=0} \Big]\,dx$$

$$= \int_0^2 \left[-x^2+2x+\frac{1}{2}\left[x^2+-4x+4\right]\right]dx = \frac{1}{2}\int_0^2\left[-2x^2+4x+x^2-4x+4\right]dx = \frac{1}{2}\int_0^2\left[-x^2+4\right]dx$$

$$= \frac{1}{2}\left[-\frac{x^3}{3}+4x\right]_0^3 = \frac{1}{2}\left[-\frac{27}{3}+4(3)\right] - \frac{1}{2}\left[-\frac{0^3}{3}+4(0)\right] = \boxed{\frac{3}{2}}.$$

(14)

(16.) $\iint_R (x^2+y^2)\,dA$ over R which is defined by the region of the circle $x^2+y^2=4$ in the 3rd Quadrant.



$0 \le r \le 2$
$\pi \le \theta \le 3\pi/2$

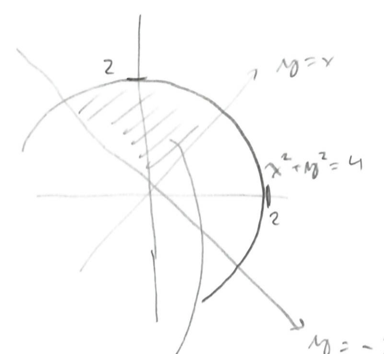
Sol'n. $\iint_R (x^2+y^2)\,dA$ $dA = r\,dr\,d\theta$

$$= \int_{\pi}^{3\pi/2}\int_0^2 (r^2)\,r\,dr\,d\theta = \iint r^3\,dr\,d\theta$$

$$= \frac{r^4}{4}\Big|_0^2 \cdot \int_{\pi}^{3\pi/2} d\theta = \left(\frac{16}{4}-\frac{0}{4}\right)\cdot\left(\frac{3\pi}{2}-\pi\right)$$

$$= \boxed{2\pi}$$

(17) $\iint_R \frac{\sqrt{\tan(y/x)}}{\sqrt{x^2+y^2}}\,dA$ over R



$\frac{\pi}{4} \le \theta \le 3\pi/4$
$0 \le r \le 2$

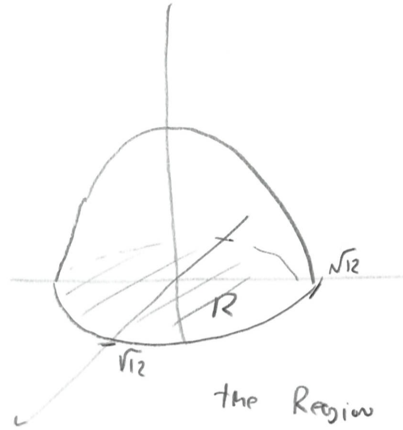
$$= \int_{\pi/4}^{3\pi/4}\int_0^2 \frac{\sqrt{\theta}}{r}\,r\,dr\,d\theta$$

$$= \iint \theta^{1/2}\,dr\,d\theta = \int \theta^{1/2}\, r\Big|_0^2\,d\theta$$

$$= \int \theta^{1/2}[2-0]\,d\theta = \frac{2}{3}\theta^{3/2}\cdot 2\Big|_{\pi/4}^{3\pi/4}$$

$$= \frac{4}{3}\left[\left(\frac{3\pi}{4}\right)^{3/2} - \left(\frac{\pi}{4}\right)^{3/2}\right].$$

18) $\boxed{z = 12 - x^2 - y^2}$



$$V = \iint (12 - x^2 - y^2)\, dA$$

$$= \int_0^{2\pi}\int_0^{\sqrt{12}} (12 - r^2)\, r\, dr\, d\theta$$

$$= \int_0^{2\pi} d\theta \int_0^{\sqrt{12}} (12r - r^3)\, dr$$

$$= \theta \Big|_0^{2\pi} \cdot \left[\frac{12r^2}{2} - \frac{1}{4}r^4\right]_0^{\sqrt{12}} = [2\pi - 0] \cdot \left[6(\sqrt{12})^2 - \frac{1}{4}(\sqrt{12})^4 - 0\right] = 2\pi[72 - 36] = \underline{72\pi}.$$

the xy-plane

the Region R is where $z = 0$ intersects $z = 12 - x^2 - y^2$

$\downarrow$

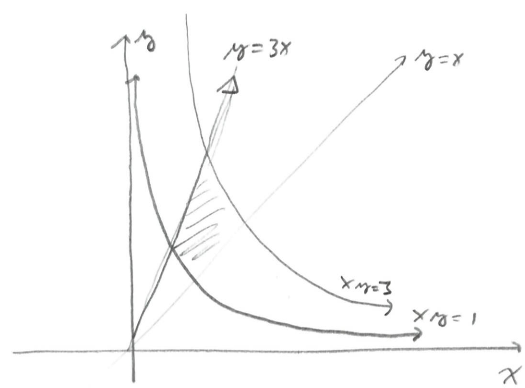
$0 = 12 - x^2 - y^2$

$x^2 + y^2 = 12$

For 19 - 23 use change of variables & Jacobians

21) $\iint_R xy\, dA =$

R: $xy = 1$ $xy = 3$ $y = x$ $y = 3x$



use $x = \frac{u}{v}$ $y = v$

TRANSFORM & its INVERSE

$T \begin{bmatrix} x = u/v \\ y = v \end{bmatrix}$ $T^{-1}\begin{bmatrix} u = xy \\ v = y \end{bmatrix}$

$x = u/v$

$x = u/y$

$xy = u$

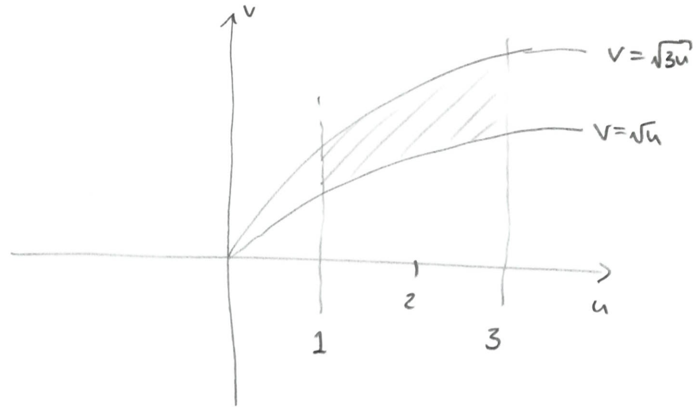
COMPUTE $J(u,v) = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{vmatrix}$

$$= \begin{vmatrix} 1/v & -uv^{-2} \\ 0 & 1 \end{vmatrix} = \frac{1}{v}$$

$xy = 1$	$xy = 3$	$y = x$	$y = 3x$
$u = 1$	$u = 3$	$v = u/v$	$v = 3\,u/v$
		$v = \sqrt{u}$	$v = \sqrt{3u}$

} Region

21 (CONTINUED)



$R\begin{cases} 1\le u\le 3 \\ \sqrt{u}\le v\le\sqrt{3u}\end{cases}$

$\iint xy \, dA$

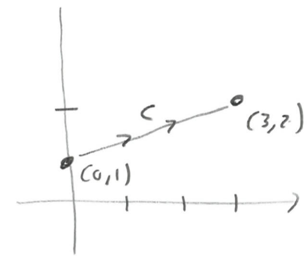
$= \iint u \, J(u,v)\, du\, dv$

$= \int_1^3 \int_{\sqrt{u}}^{\sqrt{3u}} u \cdot \frac{1}{v} \, dv\, du$

$= \int_1^3 u \cdot \ln v \Big|_{\sqrt{u}}^{\sqrt{3u}} du = \int u\left[\ln\sqrt{3u} - \ln\sqrt{u}\right] du = \int_1^3 u\left[\ln\sqrt{\frac{3u}{u}}\right] du$

$= \frac{1}{2}\ln(3)\int_1^3 u\, du = \frac{1}{2}\ln(3)\cdot\frac{u^2}{2}\Big|_1^3 = \boxed{4\ln(3)}$

24. $\int_C x\,dx$ From $(0,1)$ to $(3,2)$



$$= \int_0^1 3t \cdot 3dt = \frac{9t^2}{2}\Big|_0^1 = \boxed{\frac{9}{2} - 0}$$

$x = 0 + 3t = 3t$ $\quad dx = 3dt$

$y = 1 + t = 1+t$

↑ Pt. ↑ $V = \langle 3-0, 2-1 \rangle$

$= \langle 3, 1 \rangle$

25. $\int_C xy\,ds$ same curve $x = 3t$

$y = 1+t$

$0 \le t \le 1$

$\vec{r}(t) = \langle 3t, 1+t \rangle$

$ds = \|\vec{r}\,'(t)\|\,dt$ $\quad \vec{r}\,'(t) = \langle 3, 1 \rangle$

$= \sqrt{3^2 + 1^2}\,dt = \sqrt{10}\,dt$

$$= \int_0^1 (3t)(1+t)\sqrt{10}\,dt$$

$$= \sqrt{10}\int (3t + 3t^2)\,dt = \sqrt{10}\left[\frac{3t^2}{2} + \frac{3t^3}{3}\right]_0^1 = \sqrt{10}\left[\frac{3(1)^2}{2} + (1)^3 - 0\right] = \boxed{\frac{5}{2}\sqrt{10}}$$

26. $\int \langle -x, y \rangle \cdot d\vec{r}$

$x = 3t$ $\quad \vec{r}(t) = \langle 3t, 1+t \rangle$

$y = 1+t$ $\quad d\vec{r} = \langle 3, 1 \rangle\,dt$

$0 \le t \le 1$

$$= \int_0^1 \langle -3t, 1+t \rangle \cdot \langle 3, 1 \rangle\,dt$$

$$= \int_0^1 (-9t + (1+t))\,dt = \int_0^1 (-8t+1)\,dt = -\frac{8t^2}{2} + t = (-4t^2 + t)\Big|_0^1 = \boxed{-3}$$

30. $\oint_C \langle 1, xy \rangle \cdot d\vec{r}$

$C \to x^2 + y^2 = 4$ traced counter-clockwise

$x = 2\cos t$ $\quad \vec{r}(t) = \langle 2\cos t, 2\sin t \rangle$

$y = 2\sin t$ $\quad d\vec{r} = \langle -2\sin t, 2\cos t \rangle\,dt$

$0 \le t \le 2\pi$

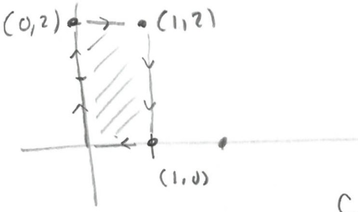
$$= \int_0^{2\pi} \langle 1, 2\cos t \cdot 2\sin t \rangle \cdot \langle -2\sin t, 2\cos t \rangle\,dt$$

used u-sub here

$$= \int_0^{2\pi} (-2\sin t + 8\cos^2 t \sin t)\,dt = \cdots = 2\cos t + -\frac{8}{3}\cos^3 t\Big|_0^{2\pi} = \cdots = \boxed{0}$$

what could this mean?

(32) $\oint_C \langle x, -y \rangle \cdot d\vec{r}$



$$\oint_C \langle L, M \rangle \cdot d\vec{r} = \iint_R \left(\frac{\partial M}{\partial x} - \frac{\partial L}{\partial y} \right) dA$$

why a negative?

$$= -\iint_R \left(\frac{\partial M}{\partial x} - \frac{\partial L}{\partial y} \right) dA$$

$$= -\iint_R \left[0 - 0 \right] dA = 0.$$

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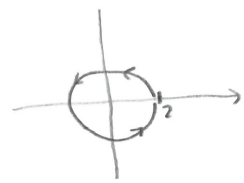
(34) $\oint_C \langle \cos(x^2) + y,\ \cos(y^2) + xy \rangle \cdot d\vec{r}$



$\vec{r}(t) = \langle 2\cos t, 2\sin t \rangle$

$\frac{\partial}{\partial x}$ $\frac{\partial}{\partial y}$

$$= \iint_R \left[y - 1 \right] dA$$

I'll use polar

$$= \int_0^{2\pi} \int_0^2 \left[r\sin\theta - 1 \right] r\,dr\,d\theta$$

$$= \int_0^{2\pi} \int_0^2 (r^2 \sin\theta - r)\,dr\,d\theta = \int_0^{2\pi} \left[\frac{r^3}{3}\sin\theta - \frac{r^2}{2} \right]_0^2 d\theta$$

$$= \int_0^{2\pi} \left[\underbrace{\left(\tfrac{8}{3}\sin\theta - 2 \right)}_{r=2} - \underbrace{\left(0 \right)}_{r=0} \right] d\theta = \int_0^{2\pi} \left(\frac{8}{3}\sin\theta - 2 \right) d\theta$$

$$= -\frac{8}{3}\cos\theta - 2\theta \Big|_0^{2\pi} = \left[-\frac{8}{3}\cos(2\pi) - 2(2\pi) \right] - \left[-\frac{8}{3}\cos(0) - 2(0) \right]$$

$$= \boxed{-4\pi}$$

35) $f(x,y,z) = x^3 - yz^2$ $\quad\quad \vec{F}(x,y,z) = \langle x^3, yz^2, xy \rangle$

grad $(f) = \vec{\nabla} f$ $\quad\quad$ div $(\vec{F}) = \vec{\nabla} \cdot \vec{F}$ $\quad\quad$ curl$(\vec{F}) = \vec{\nabla} \times \vec{F}$

(a) div $(f(x,y,z))$ undefined.

(b) grad$(f(x,y,z))$ $= \vec{\nabla} f = \langle 3x^2, -z^2, -2yz \rangle$

(c) curl(f) undefined

(d) div(F) $= \vec{\nabla} \cdot \vec{F} = \langle \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \rangle \cdot \langle x^3, yz^2, xy \rangle$

$$= \frac{\partial}{\partial x}[x^3] + \frac{\partial}{\partial y}[yz^2] + \frac{\partial}{\partial z}[xy] = 3x^2 + z^2 + 0.$$

(e) grad $(\vec{F})$ undefined

(f) curl$(\vec{F})$ $= \vec{\nabla} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x^3 & yz^2 & xy \end{vmatrix}$

$$= \hat{i}[x - 2zy] - \hat{j}[y - 0] + \hat{k}[0 - 0]$$

$$= \langle x - 2zy, -y, 0 \rangle$$

(g)

(h) $\Big\}$ you try.

(i)