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Area and volume by double integral

πa²

$A = \iint dx\,dy$

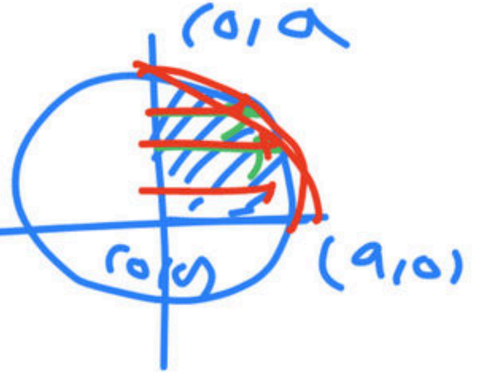
Area of the region D by double integral :

The area of the region D in the xy-plane is given by

$$A = \iint_D dx\,dy = \iint_D dA.$$

$x^2 + y^2 = a^2$

$$A = 4\int_{y=0}^{a}\int_{x=0}^{\sqrt{a^2-y^2}} dx\,dy$$



$$= 4\int_0^a (x)_0^{\sqrt{a^2-y^2}}\,dy = 4\int_0^a \sqrt{a^2-y^2}\,dy$$

$$= 4\left(\frac{y}{2}\sqrt{a^2-y^2} + \frac{a^2}{2}\sin^{-1}\left(\frac{y}{a}\right)\right)_0^a$$

$$= 4\left(\left(0 + \frac{a^2}{2}\sin^{-1}(1)\right) - (0+0)\right) = 4\,\frac{a^2}{2}\,\frac{\pi}{2}$$

$$= \pi a^2$$

$$A = \iint dx\,dy$$

$$A = 4\int_{\theta=0}^{\pi/2}\int_{0}^{a} r\,dr\,d\theta$$

$$= 4\int_{0}^{\pi/2} d\theta \int_{0}^{a} r\,dr$$

$$= 4(\theta)_0^{\pi/2}\left(\frac{r^2}{2}\right)_0^{a}$$

$$= 4\left(\frac{\pi}{2}\right)\left(\frac{a^2}{2}\right) = \pi a^2$$

$x^2 + y^2 = a^2$

$x = r\cos\theta$

$y = r\sin\theta$

Q Area of rectangle $D = \{(x,y) \mid 0 \le x \le 1, 0 \le y \le 2\}$

$$A = \iint dx\,dy$$

$$A = \int_{y=0}^{2} \int_{x=0}^{1} dx\,dy = \int_0^2 dx \int_0^1 (dy)$$

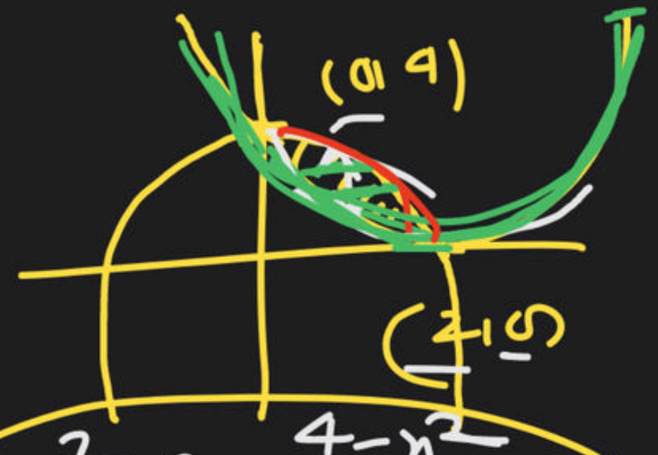
$$= (x)_0^2 (y)_0^1 = (2-0)(1-0)$$

$$= 2$$

Q Area of region enclosed by curve $y = 4 - x^2$

$y = \sqrt{4-x^2}$

$$A = \int_{y=0}^{4} \int_{x=\sqrt{y}+2}^{\sqrt{4-y}} dx\,dy$$



$$A = \int_{0}^{4} \left(\sqrt{4-y} - \sqrt{y} - 2\right) dy$$

$$A = \left[-\frac{(4-y)^{3/2}}{3/2} - \frac{y^{3/2}}{3/2} - 2y \right]_0^4$$

$$A = \left[\left(0 - \frac{4^{3/2}}{3/2} - 8\right) - \left(-\frac{4^{3/2}}{3/2}\right) \right]$$

$$A = -8$$

$$A = \int_{x=0}^{2} \int_{y=x^2-2}^{4-x^2} dy\,dx$$

Q.1. The area of the planer region bounded by the curve $x = 6y^2 - 2$ and $x = 2y^2$. **IIT-JAM 2015**

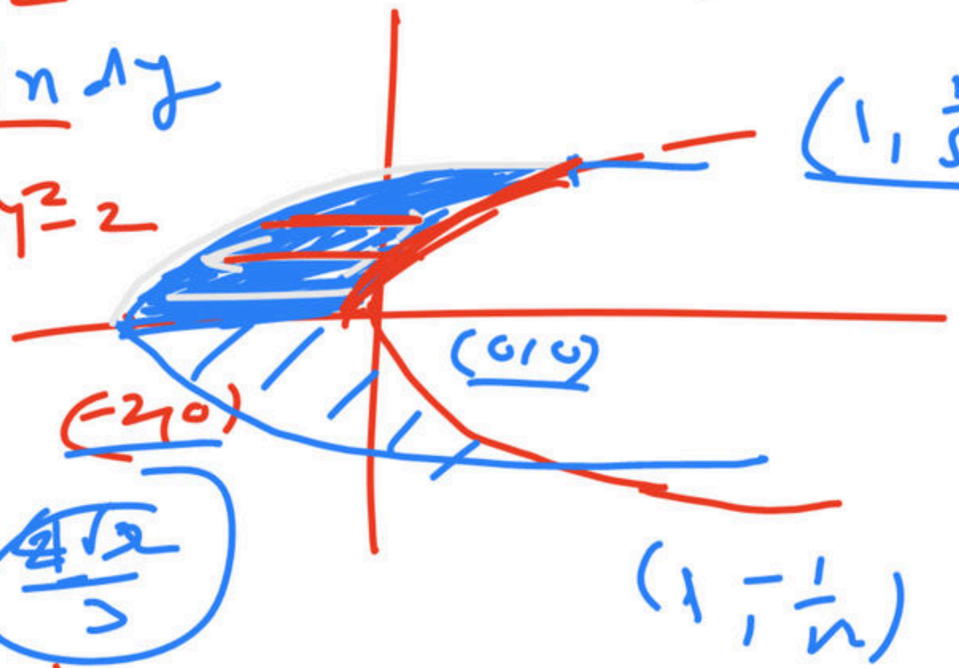
(a) $\frac{\sqrt{2}}{3}$ (b) $\frac{2\sqrt{2}}{3}$

(c) $\frac{4\sqrt{2}}{3}$ (d) $\sqrt{2}$

$2y^2 = 6y^2 - 2$

$4y^2 = 2$

$A = 2\int_{y=0}^{1/\sqrt{2}} \int_{x=6y^2-2}^{2y^2} dx\,dy$



$2\int_0^{1/\sqrt{2}} (x)_{6y^2-2}^{2y^2} dy$

$8 \times \Delta$

$3\sqrt{2} \times (\quad)$

$\frac{4\sqrt{2}}{3}$

$2\int_0^{1/\sqrt{2}} (2y^2 - 6y^2 + 2)\,dy = 2\int_0^{1/\sqrt{2}} (2 - 4y^2)\,dy$

$2\left(2y - \frac{4y^3}{3}\right)_0^{1/\sqrt{2}} = 2\left[2\frac{1}{\sqrt{2}} - \frac{4}{3}\left(\frac{1}{\sqrt{2}}\right)^3\right]$

$= \frac{2}{\sqrt{2}}\left(2 - \frac{4}{3}\frac{1}{2}\right) = \frac{2}{\sqrt{2}}\frac{4}{3}$

Q.2. The area of $\{ (x,y) \in R^2 ; |x| + |y| \leq 2\}$ is **HCU 2021**

(a) 4 (b) 8 (c) 10

(d) 5

$x+y=2$ | $x-y=2$

$-x+y=2$ | $-x-y=2$

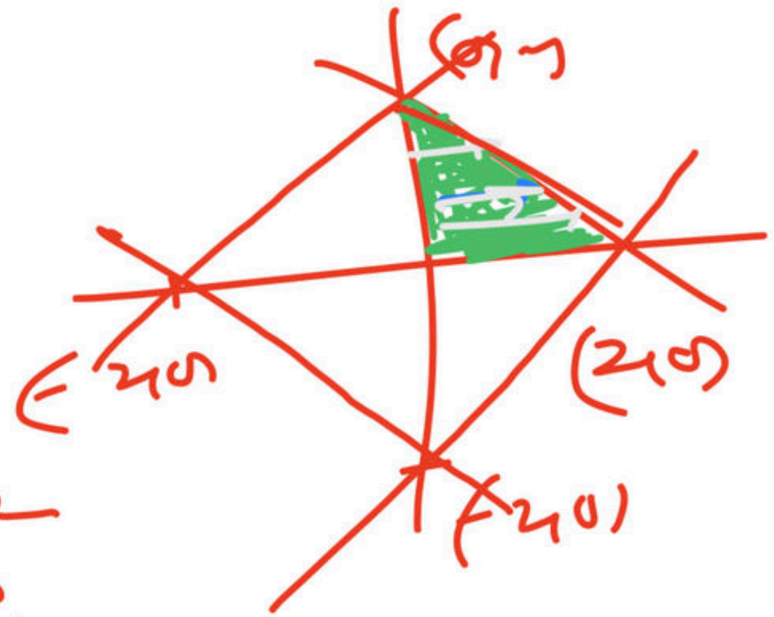
$$A = 4\int\int dx\,dy$$

$y=0$ $x=0$

$$A = 4\int_0^2 (x)_0^{2-y}\,dy$$

$$= 4\int_0^2 (2-y)\,dy = 4\left(2y - y^2/2\right)_0^2$$

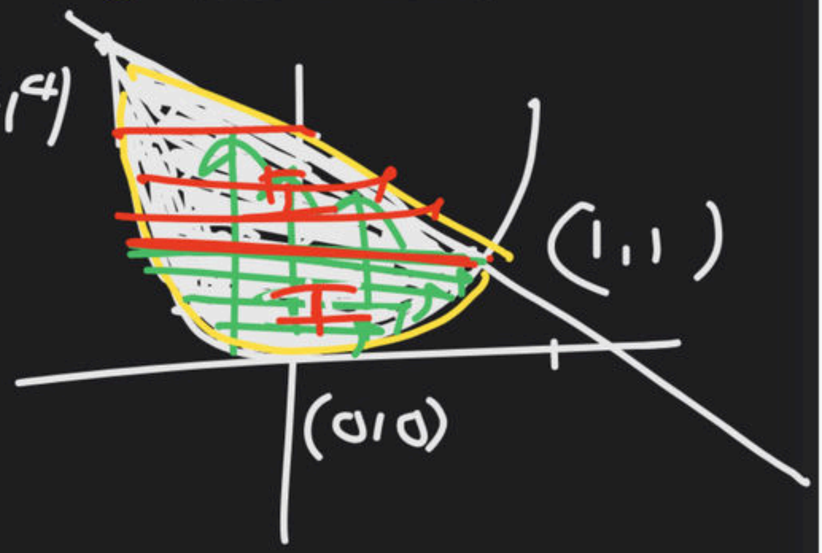
$$= 4(4 - 4/2) = 4(4-2) = 8$$



9 Area of the region bounded by $y = x^2$ and $x + y = 2$ is

(a) 3 (b) $\frac{27}{2}$

(c) $\frac{9}{2}$ (d) 9



$$A = \int_{x=-2}^{1} \int_{y=x^2}^{2-x} dy\, dx = \int_{-2}^{1} (y)_{x^2}^{2-x} dx$$

$$= \int_{-2}^{1} (2 - x - x^2)\, dx = \left[2x - \frac{x^2}{2} - \frac{x^3}{3}\right]_{-2}^{1}$$

$$= \left(\left(2 - \frac{1}{2} - \frac{1}{3}\right) - \left(-4 - \frac{4}{2} + \frac{8}{3}\right)\right)$$

$$= 2 - \frac{1}{2} - \frac{1}{3} + 4 + 2 - \frac{8}{3}$$

$8 - 3 - 1 = 4$

$5 - 1 = 4$

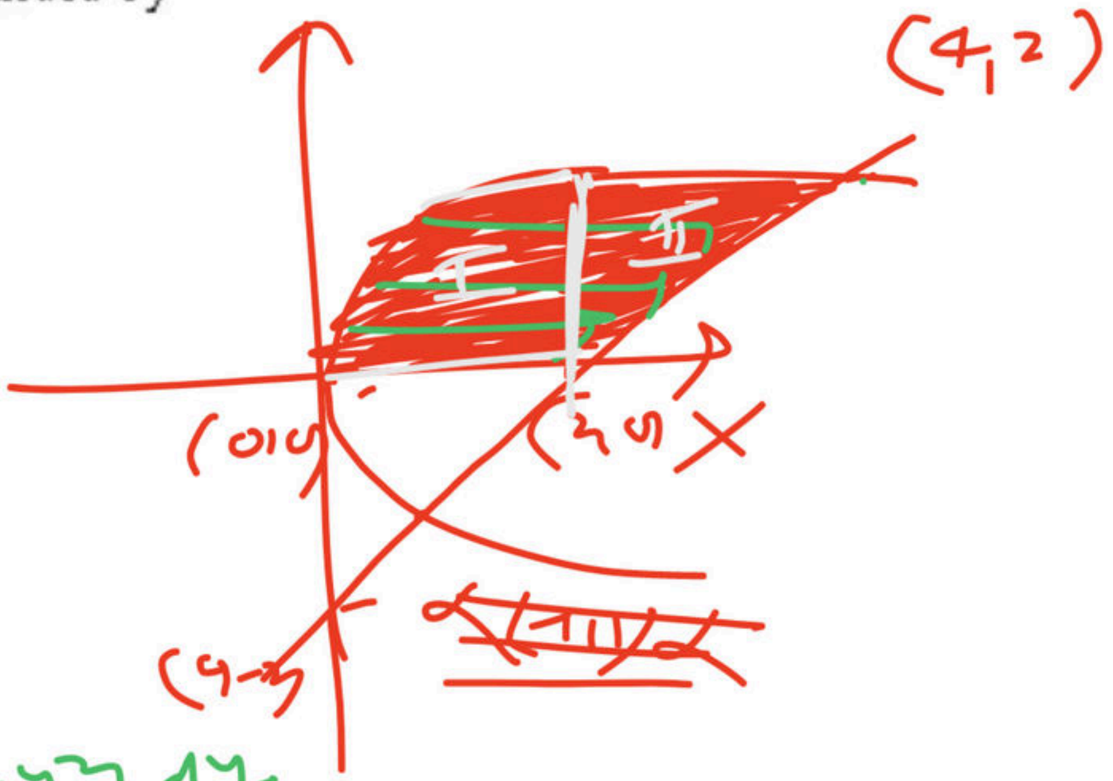
Q.3. The area of the region in the first quadrant that is bounded by $y = \sqrt{x}$, $y = x - 2$ and the x-axis

$y^2 = x$

$y + 2 = x$

(a) 1/3 (b) 10

(c) 10/3 (d) 4



$$\int_{y=0}^{2} \int_{x=y^2}^{y+2} dx\,dy$$

$$\int_{y=0}^{2} (x)_{y^2}^{y+2} dy = \int_0^2 (y+2-y^2)\,dy$$

$$= \left(y^2/2 + 2y - y^3/3\right)_0^2$$

$$= \left(4/2 + 4 - 8/3\right) = \left(6 - 8/3\right) = 10/3$$

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Q4. Area enclosed by the curve $y^2 = x$ and $y^2 = 2x - 1$ lying in the first quadrant is **IIT JAM – 2005**

(a) 1/6 (b) 1/4

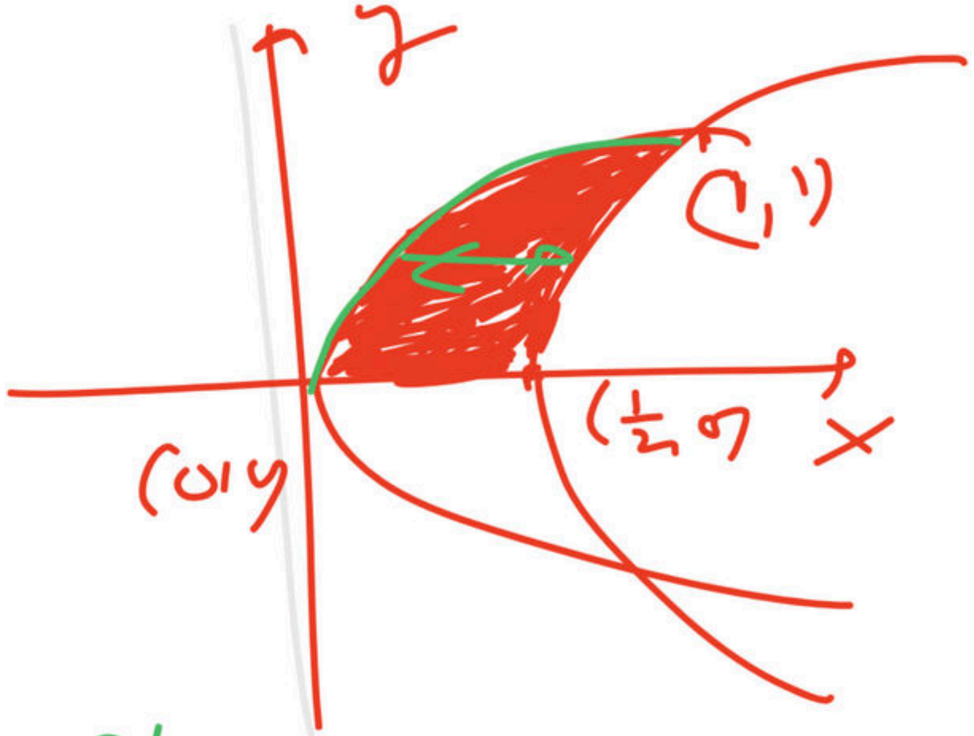
(c) 1/2 (d) 1/3

$x = 2y - 1$

$\frac{y^2+1}{2}$

$$\int_0^1 \int_{y^2}^{\frac{y^2+1}{2}} dx\,dy = \int_0^1 (x)_{y^2}^{\frac{y^2+1}{2}} dy$$

$y = 0 \quad x = y^2$



$$= \int_0^1 \left(\frac{y^2+1}{2} - y^2\right) dy = \int_0^1 \left(\frac{1-y^2}{2}\right) dy$$

$$= \frac{1}{2}\left(y - \frac{y^3}{3}\right)_0^1 = \frac{1}{2}\left(1 - \frac{1}{3}\right)$$

$$= \frac{1}{2}\left(\frac{2}{3}\right) = \frac{1}{3}$$

Q.5. Consider the open rectangle $G = \{(s,t) \in R^2 : 0 < s < 1$ and $0 < t < 1\}$ and the map $T : G \to R^2$ given by $T(s,t) = \left(\frac{\pi s(1-t)}{2}, \frac{\pi(1-s)}{2} \right)$ for $(s,t) \in G$ Then the area of the image T(G) of the map T is equal to **IIT JAM 2022**

(a) $\pi/4$ (b) $\pi^2/4$

(c) $\pi^2/8$ (d) 1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