1. $\displaystyle\int \frac{3}{t^2}\,dt =$

   (a) $\dfrac{3}{t} + C$

   (b) $\boxed{-\dfrac{3}{t} + C}$

   (c) $\dfrac{6}{t^3} + C$

   (d) $-\dfrac{6}{t^3} + C$

   We have

$$\begin{aligned}\int \frac{3}{t^2}\,dt &= \int 3t^{-2}\,dt \\ &= \frac{3}{-1t^{-1}} + C \\ &= -\frac{3}{t} + C.\end{aligned}$$

2. The area under the graph of $f(x) = \sqrt[3]{x}$ from $x = 2$ to $x = 5$ is

   (a) $\displaystyle\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i}\right)$

   (b) $\displaystyle\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i} \cdot \frac{2}{n}\right)$

   (c) $\boxed{\displaystyle\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i} \cdot \frac{3}{n}\right)}$

   (d) $\displaystyle\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i} \cdot \frac{5}{n}\right)$

   The formula for the area under $f(x)$ from $x = a$ to $x = b$ is

$$\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i}\Delta x\right),$$

   where $\Delta x = \frac{b-a}{n}$. In this case $\Delta x = \frac{5-2}{n} = \frac{3}{n}$, so the formula is $\displaystyle\lim_{n\to\infty}\left(\sum_{i=1}^{n} \sqrt[3]{x_i} \cdot \frac{3}{n}\right)$.

3. $\int_0^4 |x-2|\,dx =$

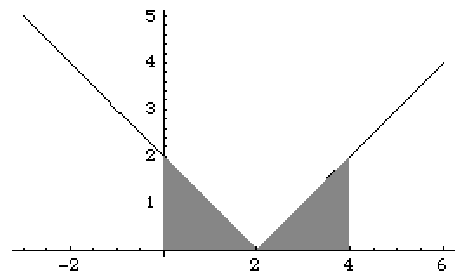
(a) 0

(b) 2

(c) $\boxed{4}$

(d) does not exist.

$\int_0^4 |x-2|\,dx$ represents the combined area of the regions shown at right, which is 4 (each triangle has area 2).



4. $\int_0^{\pi/2} 5\sin\theta\,d\theta =$

(a) 10

(b) 0

(c) -5

(d) $\boxed{5}$

We have

$$\begin{aligned}\int_0^{\pi/2} 5\sin\theta\,d\theta &= -5\cos\theta\,\Big|_0^{\pi/2}\\ &= -5\left(\cos\left(\tfrac{\pi}{2}\right) - \cos 0\right)\\ &= -5(0-1) = 5.\end{aligned}$$

5. $\int_0^1 x^2(1+x^3)^4\,dx =$

(a) $\frac{32}{5}$

(b) $\frac{32}{15}$

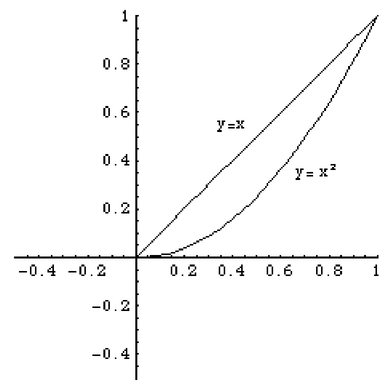
(c) $\frac{31}{5}$

(d) $\boxed{\frac{31}{15}}$

Let $u = 1 + x^3$. Then $du = 3x^2\,dx$, and we get

$$\begin{aligned}\int_0^1 x^2(1+x^3)^4\,dx &= \frac{1}{3}\int_0^1 3x^2(1+x^3)^4\,dx \\ &= \frac{1}{3}\int_?^? u^4\,du = \frac{1}{3}\cdot\frac{u^5}{5}\,\Big|_?^? \\ &= \frac{1}{15}(1+x^3)^5\,\Big|_0^1 \\ &= \frac{1}{15}\left((1+1^3)^5 - (1+0^3)^5\right) \\ &= \frac{1}{15}(32-1) = \frac{31}{15}.\end{aligned}$$

6. The area of the region shown is



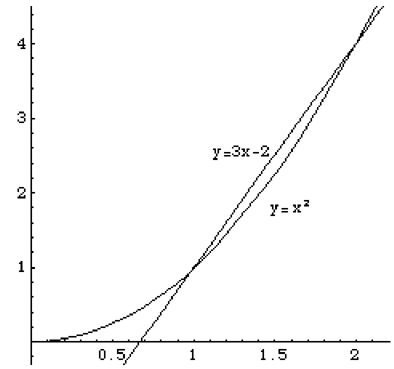
   (a) $\frac{1}{9}$
   (b) $\frac{1}{7}$
   (c) $\boxed{\frac{1}{6}}$
   (d) $\frac{1}{4}$

Since $y = x$ is the curve on top and $y = x^2$ is the curve on the bottom, the area is

$$\begin{aligned}\int_0^1 (x - x^2)\,dx &= \frac{x^2}{2} - \frac{x^3}{3}\,\Big|_0^1 \\ &= \frac{1}{2} - \frac{1}{3} = \frac{1}{6}.\end{aligned}$$

7. The volume of the solid formed by rotating the region enclosed by the curves $y = x^2$ and $y = 3x - 2$ about the x-axis is

   (a) $2\pi \int_1^2 x(3x - 2 - x^2)\,dx$
   (b) $2\pi \int_1^2 x(x^2 - (3x-2))\,dx$
   (c) $\boxed{\pi \int_1^2 ((3x-2)^2 - x^4)\,dx}$
   (d) $\pi \int_1^2 (x^4 - (3x-2)^2)\,dx$



The region is shown above. From the answer choices you can see that the curves intersect at $x = 1$ and $x = 2$ (or you can set $x^2 = 3x - 2$ and solve for x). Since we are rotating a region formed by functions of x about a *horizontal* axis, we should use the **disk** method. Therefore we have $R = 3x - 2$ and $r = x^2$, and the volume is

$$V = \pi \int_1^2 ((3x-2)^2 - (x^2)^2)\, dx.$$

8. The volume of the solid formed by rotating the region enclosed by the curves $y = x^2$ and $y = 3x - 2$ about the y-axis is

   (a) $\pi\left(7 - \frac{33}{5}\right)$

   (b) $\pi\left(15 - \frac{33}{5}\right)$

   (c) π

   (d) $\boxed{\frac{\pi}{2}}$

This is the same region as in #7, but this time we are rotating about a *vertical* axis. So we use the **shell** method, and the volume is

$$\begin{aligned} V &= 2\pi \int_1^2 x(3x - 2 - x^2)\, dx \\ &= 2\pi \int_1^2 (3x^2 - 2x - x^3)\, dx \\ &= 2\pi \left(x^3 - x^2 - \tfrac{1}{4}x^4\right)\Big|_1^2 \\ &= 2\pi \left((8 - 4 - 4) - \left(1 - 1 - \tfrac{1}{4}\right)\right) \\ &= 2\pi \left(0 - \left(-\tfrac{1}{4}\right)\right) \\ &= \frac{\pi}{2}. \end{aligned}$$

9. If 24 lbs. of force are required to stretch a spring 18 in. (= 1.5 ft.) beyond its natural length, which expression best represents the work done in stretching the spring 10 ft. beyond its natural length? *Hint.* Remember Hooke's Law: $F(x) = kx$.

(a) $\boxed{\int_0^{10} 16x\,dx}$

(b) $\int_0^{10} \frac{4}{3}x\,dx$

(c) $\int_0^{1.5} 10x\,dx$

(d) $\int_0^{1.5} 8x\,dx$

By Hooke's Law, $24 = k \cdot 1.5$ for this spring, so the spring constant is $k = \frac{24}{1.5} = \frac{48}{3} = 16$. Therefore the force on the spring when stretched x units beyond its natural length is $F(x) = 16x$, and the work done to stretch it 10 ft. is $\int_0^{10} 16x\,dx$.

10. The average value of the function $f(x) = \sin\left(\frac{\pi}{2}x\right)$ on the interval $[0, 2]$ is

(a) $\boxed{\frac{2}{\pi}}$

(b) $\frac{4}{\pi}$

(c) $\frac{1}{\pi}$

(d) $\frac{3}{\pi}$

The average value of $f(x) = \sin\left(\frac{\pi}{2}x\right)$ on the interval $[0, 2]$ is

$$\frac{1}{2}\int_0^2 \sin\left(\frac{\pi}{2}x\right)\,dx = \frac{1}{2}\cdot\frac{2}{\pi}\left(-\cos\left(\frac{\pi}{2}x\right)\right)\Big|_0^2$$

use a u-substitution with $u = \frac{\pi}{2}x$ as in the practice midterm, #13.

$$\begin{aligned} &= -\frac{1}{\pi}(\cos\pi - \cos 0) \\ &= -\frac{1}{\pi}(-1-1) = \frac{2}{\pi}. \end{aligned}$$

BONUS. (5 points) The volume of the solid formed by rotating the rectangle with vertices $(2, 2)$, $(3, 3)$, $(5, 1)$, and $(4, 0)$ about the line $y = -x + 2$ is

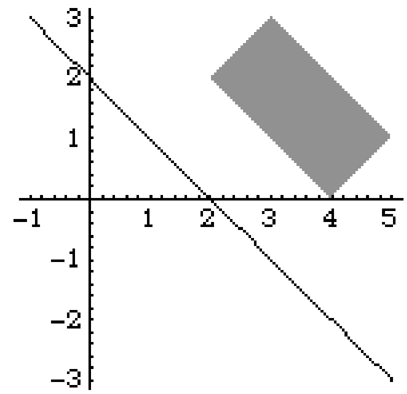
(a) 4π

(b) 8π

(c) $4\pi\sqrt{2}$

(d) $8\pi\sqrt{2}$

(e) $\boxed{12\pi\sqrt{2}}$



The rectangle is shown along with the line $y = -x + 2$. When rotated about the line, the rectangle makes a cylinder with inner radius $r = \sqrt{2}$, outer radius $R = 2\sqrt{2}$, and height $h = 2\sqrt{2}$. Therefore the volume is

$$\begin{aligned} V &= \pi(R^2 - r^2)h \\ &= \pi((2\sqrt{2})^2 - (\sqrt{2})^2)2\sqrt{2} \\ &= \pi(8 - 2)2\sqrt{2} = 12\sqrt{2}. \end{aligned}$$