

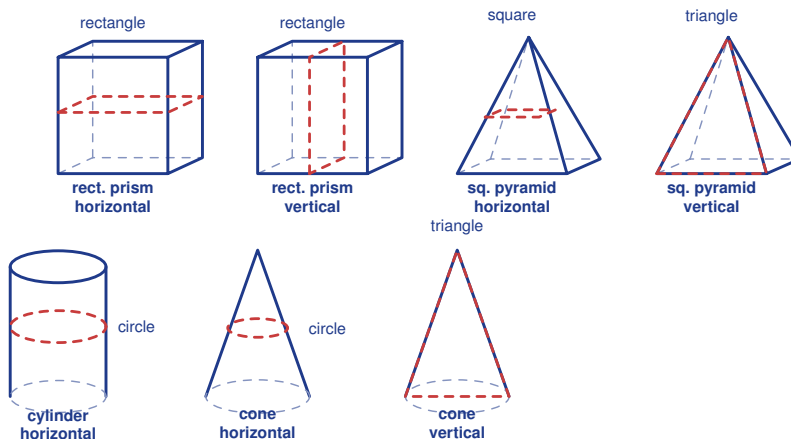
# Cross Sections of 3-D Figures

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Imagine slicing a 3-D solid with a perfectly flat plane—the shape you see on the cut surface is called a **cross section**. The fascinating part is that the *same* solid can produce different cross sections depending on how you make the cut! A horizontal slice, a vertical slice, and a diagonal slice through a cylinder, for example, give very different shapes. Cross sections are a wonderfully visual way to connect 2-D and 3-D geometry.



## Key Concepts & Quick Review

- **Rectangular prism:** horizontal → rectangle; vertical (parallel to face) → rectangle; diagonal → rectangle or parallelogram.
- **Square pyramid:** horizontal → square (smaller toward apex); vertical through apex → triangle.
- **Cylinder:** horizontal → circle; vertical → rectangle; diagonal → ellipse.
- **Cone:** horizontal → circle; vertical through apex → triangle (isosceles).
- **Sphere:** any cut through centre → circle (great circle); off-centre → smaller circle.

## Examples

① A rectangular prism ( $10\text{ cm} \times 6\text{ cm} \times 4\text{ cm}$ ) is sliced horizontally halfway up. Describe the cross section and find its area.

**Think It Through:** A horizontal cut is parallel to the base, so the cross section has the same shape as the base. The base of this prism is a  $10\text{ cm}$  by  $6\text{ cm}$  rectangle, so the slice is also a rectangle with those dimensions. Its area is therefore  $10 \times 6 = 60\text{ cm}^2$ . The height of the cut does not change the shape or area in a prism like this.

**Answer:** *Rectangle*  $10 \times 6$ ; *area*  $= 60\text{ cm}^2$



② A square pyramid with base  $8\text{ cm}$  is cut by a plane parallel to the base at half the vertical height. What shape is the cross section and what is its side length?

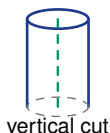
**Think It Through:** A cut parallel to the base of a pyramid makes a smaller, similar copy of the base, so the cross section is a square. Because the cut is halfway from the apex to the base, every linear measurement is scaled by  $\frac{1}{2}$ . That makes the side length  $\frac{1}{2} \times 8 = 4\text{ cm}$ . Once the side is known, the area is  $4^2 = 16\text{ cm}^2$ .

**Answer:** Square with side  $4\text{ cm}$ ; area =  $16\text{ cm}^2$

**Practice Problems**

Name the shape of each cross section or find the area/dimensions asked.

1. A cube is sliced by a horizontal plane parallel to its base. What is the cross-section shape? \_\_\_\_\_
2. A cube is sliced by a vertical plane parallel to one face. What is the cross-section shape? \_\_\_\_\_
3. A cube is sliced by a diagonal plane that cuts across opposite faces. What is the cross-section shape? \_\_\_\_\_
4. A square pyramid is sliced by a horizontal plane parallel to its base. What is the cross-section shape? \_\_\_\_\_
5. A square pyramid is sliced by a vertical plane through its apex. What is the cross-section shape? \_\_\_\_\_
6. A cylinder is sliced by a horizontal plane parallel to its circular bases. What is the cross-section shape? \_\_\_\_\_
7. A cylinder is sliced by a vertical plane through its height. What is the cross-section shape? \_\_\_\_\_



8. A cylinder is sliced by a diagonal plane that is not parallel to the base. What is the cross-section shape? \_\_\_\_\_



9. A cone is sliced by a horizontal plane parallel to its base. What is the cross-section shape? \_\_\_\_\_



10. A cone is sliced by a vertical plane through its apex. What is the cross-section shape? \_\_\_\_\_





11. A sphere is sliced by any flat plane through its center. What is the cross-section shape? \_\_\_\_\_
12. A rectangular prism measures 10 by 8 by 6. A horizontal cut is parallel to the 10 by 8 base. Find the cross-section area. \_\_\_\_\_
13. A square pyramid has base side length 12. A horizontal cut is made one-third of the way up from the base. Find the side length of the cross section. \_\_\_\_\_
14. A square pyramid has base side length 9. A horizontal cut is made two-thirds of the way up from the base. Find the side length of the cross section. \_\_\_\_\_
15. A cylinder has radius 5. A horizontal cut is parallel to its base. Find the cross-section area. \_\_\_\_\_

**Study Tips**

- Direction determines shape.** A cut parallel to the base gives a scaled copy of the base. A cut through the apex gives a triangle.
- For a pyramid cut at fraction  $f$  of the height from the apex, every linear dimension of the cross section is  $f$  times the base dimension.
- Real-world cross sections appear in MRI/CT scans, sawing timber, cooking (slicing fruit), and engineering blueprints — recognising them is a genuinely useful skill!

**Word Problems**

16. A block of cheese is shaped like a rectangular prism, 24 *cm* long, 12 *cm* wide, and 8 *cm* tall. A chef slices it with three different cuts: (a) horizontally at half-height, (b) vertically along the length, (c) diagonally from one top edge to the opposite bottom edge. Describe the shape and dimensions of each cross section, and find its area. \_\_\_\_\_
17. A traffic cone is a solid cone with base radius 15 *cm* and height 40 *cm*. A road worker cuts it with a horizontal plane 10 *cm* from the top. What shape is the cross section? Using similar triangles, find the radius of the cross section. Find the area of the cross section. \_\_\_\_\_



## Answer Keys

- |                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1) square</p> <p>2) rectangle</p> <p>3) rectangle or parallelogram</p> <p>4) square</p> <p>5) triangle</p> <p>6) circle</p> <p>7) rectangle</p> <p>8) ellipse</p> <p>9) circle</p> | <p>10) triangle</p> <p>11) circle</p> <p>12) 80</p> <p>13) 8</p> <p>14) 3</p> <p>15) 78.5</p> <p>16) (a) <math>288 \text{ cm}^2</math>; (b) <math>192 \text{ cm}^2</math>; (c) rectangle, about <math>345.6 \text{ cm}^2</math></p> <p>17) Circle; radius <math>3.75 \text{ cm}</math>; area about <math>44.2 \text{ cm}^2</math></p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Step-by-Step Explanations

**Strategy:** For Area of Circles, use radius for circle area every time, dividing the diameter by two first if the problem gives diameter. For circle area, mark the radius first; the formula depends on it.

**Practice 1:** Find the area of a circle with radius  $4 \text{ cm}$ . **Answer:**  $50.24 \text{ cm}^2$

For the first worked item, use  $A$  equals pi  $r$  squared, making sure  $r$  is the radius.

**Practice 15:** Find the exact area of a circle with radius  $3$ . **Answer:**  $9\pi$

Near the end of this topic, use  $A$  equals pi  $r$  squared, making sure  $r$  is the radius.

#### Word-problem notes:

**16. Answer:** A:  $254.34 \text{ m}^2$ ; B:  $452.16 \text{ m}^2$ ; difference:  $197.82 \text{ m}^2$ ; A:  $\approx 5.1 \text{ hr}$ ; B:  $\approx 9.0 \text{ hr}$ .

Find each pond area with  $A = \pi r^2$ . Pond A has area  $\pi(9)^2 = 81\pi \approx 254.34 \text{ m}^2$ , and Pond B has area  $\pi(12)^2 = 144\pi \approx 452.16 \text{ m}^2$ . Subtract to compare them:  $452.16 - 254.34 = 197.82 \text{ m}^2$ . To find the treatment time, divide each area by the crew's rate of  $50 \text{ m}^2$  per hour. That gives about  $5.1$  hours for Pond A and  $9.0$  hours for Pond B.

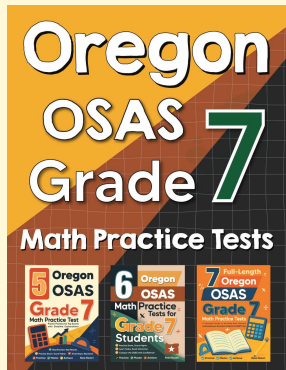
**17. Answer:** Whole:  $\pi(14)^2 \approx 615.44 \text{ cm}^2$ ; slice:  $\approx 76.93 \text{ cm}^2$ ; volume:  $\approx 384.6 \text{ cm}^3$ .

Start by converting the diameter to radius:  $28 \div 2 = 14 \text{ cm}$ . The whole cake area is  $\pi(14)^2 = 196\pi \approx 615.44 \text{ cm}^2$ . Since the cake is cut into 8 equal slices, divide by 8 to get one slice area: about  $76.93 \text{ cm}^2$ . The slice volume is approximately area times height, so  $76.93 \times 5 \approx 384.6 \text{ cm}^3$ .



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