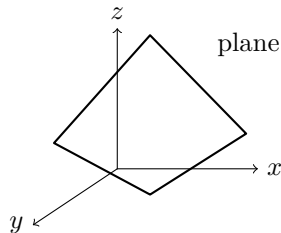


**Question 4**

Express the plane  $x + y + z = 4$  in cylindrical coordinates. Solve for  $r$  where possible and state the angles at which that solved form breaks down.

## Question 4 – Solution

**Strategy** Substitute  $x = r \cos \theta$  and  $y = r \sin \theta$ .



**Equation**

$$r(\cos \theta + \sin \theta) + z = 4.$$

If  $\cos \theta + \sin \theta \neq 0$ , then

$$r = \frac{4 - z}{\cos \theta + \sin \theta}.$$

**Exceptional angles**  $\cos \theta + \sin \theta = 0$  when  $\theta = 3\pi/4$  or  $7\pi/4$  modulo  $2\pi$ . At those directions, the original cylindrical equation reduces to  $z = 4$ ; dividing by the zero angular factor would incorrectly discard or invent points.