Step-1

Consider the vector as follows,

$$a = (1,1,......,1)$$

This vector is in $\mathbb{R}^n$ and $b = (1,0,......,0)$ to be a unit vector in any coordinate direction.

Suppose that $b = (1,0,......,0)$ is the unit vector along the x-axis.

Let θ be the angle between *a* and *b*.

Then, angle between *a* and *b* is,

$$\cos\theta = \frac{a \cdot b}{|a||b|}$$

Compute $a \cdot b$:

$$\begin{aligned} a \cdot b &= (1,1,\ldots,1)\cdot(1,0,\ldots,0) \\ &= 1+0+........+0 \\ &= 1 \end{aligned}$$

Compute $|a|$ and $|b|$:

$$\begin{aligned} |a| &= \sqrt{1^2+1^2+\cdots+1^2} \\ &= \sqrt{n} \end{aligned}$$

And,

$$\begin{aligned} |b| &= \sqrt{1^2+0^2+\cdots+0^2} \\ &= \sqrt{1} \\ &= 1 \end{aligned}$$

Step-2

Therefore,

$$\begin{aligned} \cos\theta &= \frac{1}{\sqrt{n}.1} \\ &= \frac{1}{\sqrt{n}} \end{aligned}$$

Therefore, the angle between and any coordinate axis is $\boxed{\theta = \cos^{-1}\left(\frac{1}{\sqrt{n}}\right)}$.

Step-3

It is known that the projection p of b upon a is,

$$p = \left(\frac{a \cdot b}{a \cdot a}\right) a$$

Compute $a \cdot b$ and $a \cdot a$;

$$\begin{aligned} a \cdot b &= (1,1,\ldots,1)\cdot(1,0,\ldots,0) \\ &= 1+0+\ldots\ldots+0 \\ &= 1 \end{aligned}$$

And,

$$\begin{aligned} a \cdot a &= (1,1,\ldots,1)\cdot(1,1,\ldots,1) \\ &= 1^2+1^2+\cdots+1^2 \\ &= 1+1+1+\cdots+1 \\ &= n \end{aligned}$$

So the projection of any coordinate vector into a is:

$$\begin{aligned} \frac{1}{n}a &= \frac{1}{n}(1,1,\ldots,1) \\ &= \left(\frac{1}{n},\frac{1}{n},\cdots,\frac{1}{n}\right) \end{aligned}$$

Since P is the matrix of the orthogonal projection from $\mathbb{R}^n$ onto the range of b, then the j^{th} column of P is same as what P does to the j^{th} standard basis vector.

It can be see that the matrix of P is an $n \times n$ matrix with $\frac{1}{n}$ in each entry.Â

Therefore, projection matrix P is:

$$\boxed{\frac{1}{n}\begin{bmatrix} 1 & 1 & 1 & \ldots & 1 \\ 1 & 1 & 1 & \ldots & 1 \\ 1 & 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & 1 & \cdots & 1 \end{bmatrix}}$$