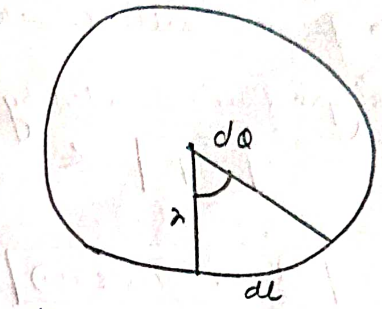
Radiometry Concepts:

- Radiometry concept useful for understanding Image Intensity.

Step 1: Angles

Angle in 2D (simplest step)

$$\boxed{d\theta = \frac{dl}{r}}$$



Unit : radian (rad)

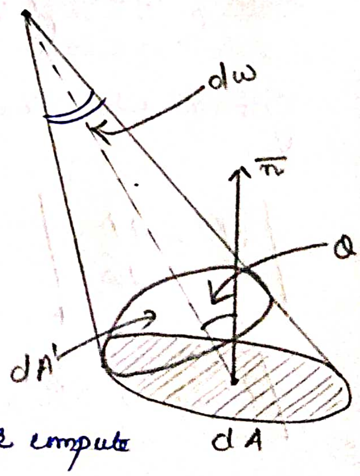
- Dimensionless Quantity as dl is in distance & r also.
- However to distinguish from other dimensionless Quantities, we use Radian.

Angle — $d\theta$
Radii — r
Arc — dl

where $\boxed{\text{Angle} = \frac{\text{Arc}(dl)}{R(r)}}$

Angle in 3D (Solid Angle).

$$d\omega = \frac{dA'}{r^2} = \boxed{\frac{dA \cdot \cos\theta}{r^2}}$$



Unit : steradian (sr)

- Dimensionless Quantity.
- To find out the 3D angle, subtended by dA, we ~~take~~ compute the foreshortened Area dA' where

$$dA' = dA \cdot \cos\theta$$

[dA': forshortened Area]

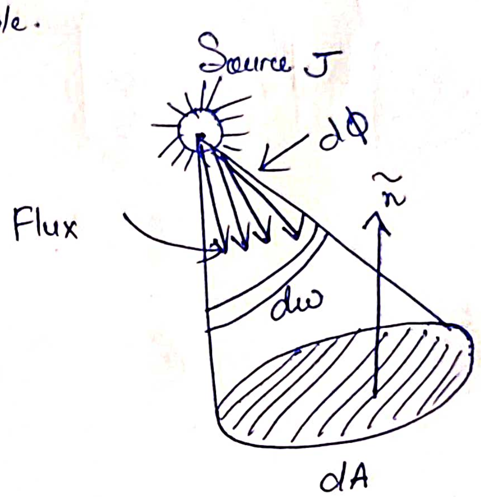
- There is a point that is looking at the infinitesimally angle dA.
- What is the Solid Angle Subtended by the area (dA).

- Solid angle subtended by a hemisphere $\rightarrow \boxed{2\pi}$
  Sphere $\rightarrow \boxed{4\pi}$

② Light Flux:

→ power emitted within a solid angle.

→ Light flux denoted by $\boxed{d\phi}$



$\boxed{\text{Unit: watts (W)}}$

- The light source J illuminates the surface of dA,
- dω → solid angle.
- flux emitted within dω is denoted by dϕ

- Radiant Intensity: (Brightness)

→ Light flux emitted per unit solid angle

→ $\boxed{J = \frac{d\phi}{d\omega}}$ Radiant intensity = $\left(\frac{\text{flux emitted by the source}}{\text{Unit solid angle}}\right)$

$\boxed{\text{Unit} \rightarrow W\, sr^{-1}}$

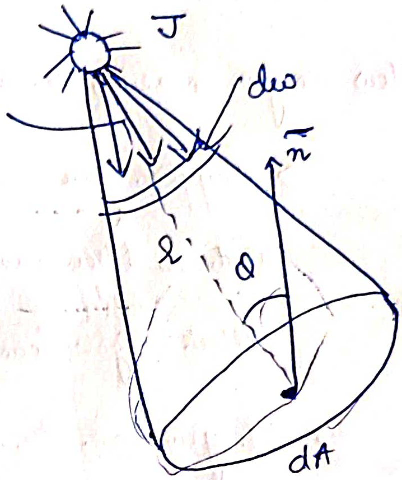
Sr – steradian

- **Surface Irradiance : (E)** (Illumination of the Surface)

↳ Light flux incident per unit surface area.

$$\boxed{E = \frac{d\phi}{dA}}$$

$$\boxed{\text{Unit} = Wm^{-2}}$$



$$E = \frac{J \cdot d\omega}{dA}$$

Substituting dω value in the above equation.

$$E = \frac{J \cdot \frac{dA \cdot \cos\theta}{r^2}}{dA}$$ (Angle in 3D)

$$= \boxed{\frac{J \cdot \cos\theta}{r^2}}$$

$\cos\theta \rightarrow$ (angle b/t direction of light source & the surface orientation.)

when you are on top of the surface, Irradiance is Maximum

Since

$$\boxed{(\text{cosine } 0 = 1)}$$

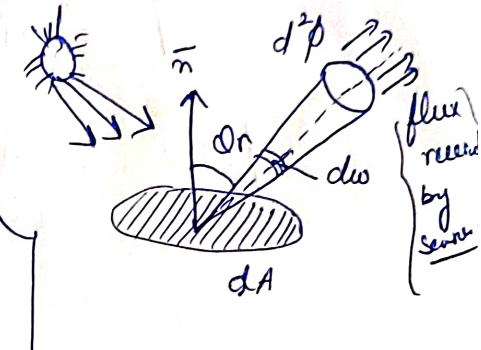
(4) Surface Radiance : (Brightness of Surface).

Light flux emitted per unit foreshortened area per unit solid angle.

How do you measure the brightness of a Surface?

→ Suppose you have an object say "Scale", and on other hand, you have a sensor that collect light from that object.

→ If you move the sensor far away from the object, the surface will receive less light



$dA \cos\theta_r$: Foreshortened Area.

→ Solid angle with respect to each point on dA reduces as you move away.

$$\boxed{L = \frac{d^2\phi}{(dA \cdot \cos\theta_r) \cdot d\omega}}$$

$d\omega$ → (Solid angle)

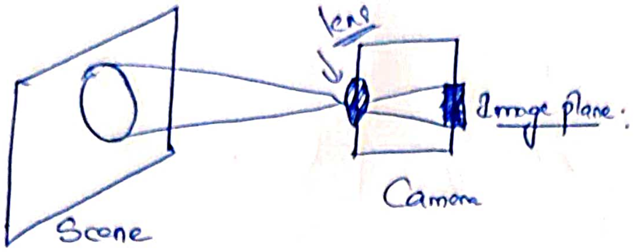
$\dfrac{\text{flux received by Sensor}}{\text{Solid angle} \cdot \text{FA}}$.

$$\boxed{\text{Unit} = W\, m^{-2}\, sr^{-1}}$$

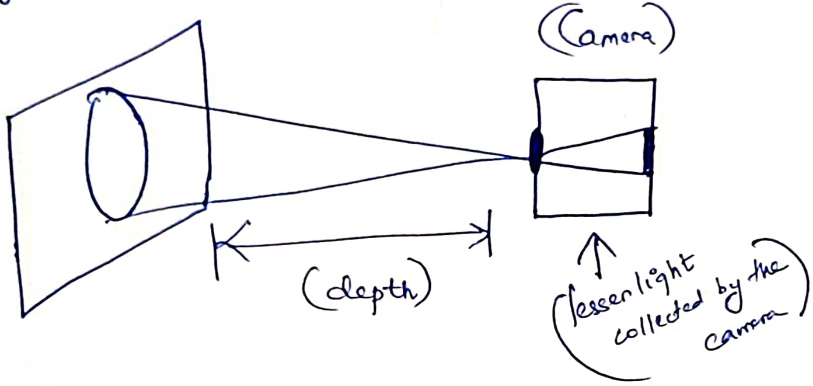
Radiance properties : → Radiance depends on :

- L depends on direction θ_r : $L(\theta_r)$
  - Surface can radiate into the whole hemisphere.
- L depends on Reflectance properties of Surface (material prop.

Explanation:



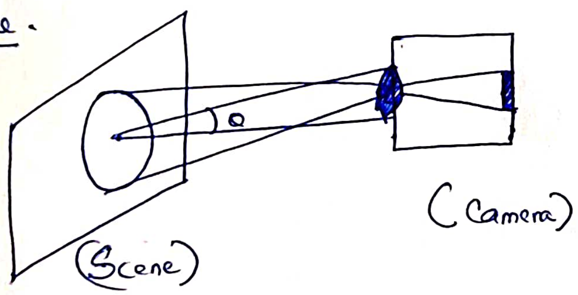
(Pulling the camera back will increase the area on the scene) → (View greater area)



Pixel is going to accumulate larger area on the scene.

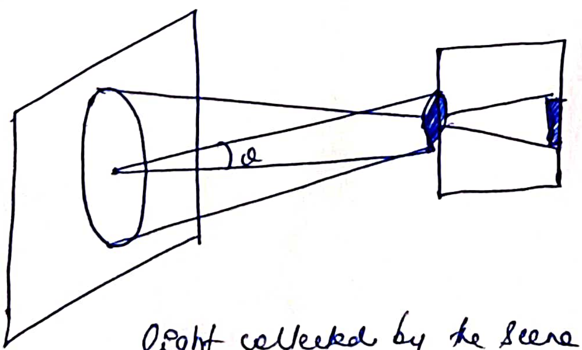
↳ The larger the scene depth, the larger the area of light accumulation.
(not the brightness)

On the other hand, we also have solid angle subtended by the lens on the scene.



θ → (governs how much light is being collected by the scene).

$\boxed{\text{θ decreases as camera moves away}}$

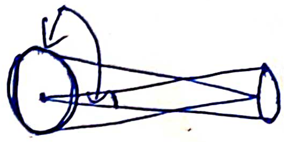


$$\left(\theta \propto \frac{1}{\text{Area of light Accumulated}} \right)$$

light collected by the scene (SA on whi

↳ Pulling lens away (greater area)

↳ angle subtended by the lens (lens size)



Summary:

→ Larger the scene depth, smaller the solid angle subtended by each point onto the lenses and hence, less light from each point.