Electric Flux

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Electric Flux and Potential

I. Electric Flux
- flux defined
- Gauss's Law

II. Electric Potential
- work and energy of charge
- potential defined
- potential of discrete charge(s)
- potential of charge distributions
- field related to potential

III. Conductors

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	The student will be able to:	HW:
1	Define and apply the concept of electric flux and solve related problems.	1 – 5
2	State and apply Gauss’s Law and solve related problems using Gaussian surfaces.	6 – 17
3	Calculate work and potential energy for discrete charges and solve related problems including work to assemble or disassemble.	18 – 25
4	Define and apply the concept of electric potential and solve related problems for a discrete set of point charges and/or a continuous charge distribution.	26 – 32
5	Use the electric field to determine potential or potential difference and solve related problems.	33 – 36
6	Use potential to determine electric field and solve related problems.	37 – 39
7	State the properties of conductors in electrostatic equilibrium and solve related problems.	40 – 46

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Flux

- The word **flux** basically means *flow*.
- Before studying electric flux (an abstraction) let us consider two examples of flux that are more concrete: light and rain.

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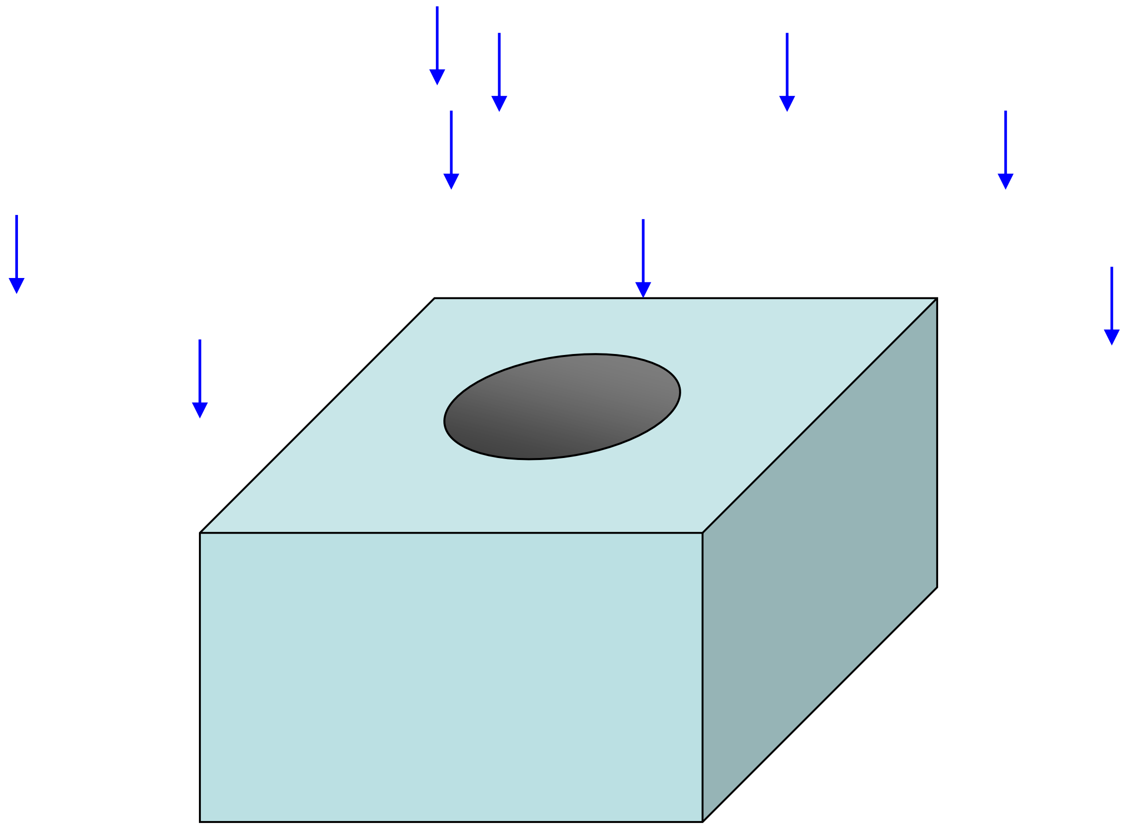
Suppose this box is left out in the rain. What will determine how much water it collects?



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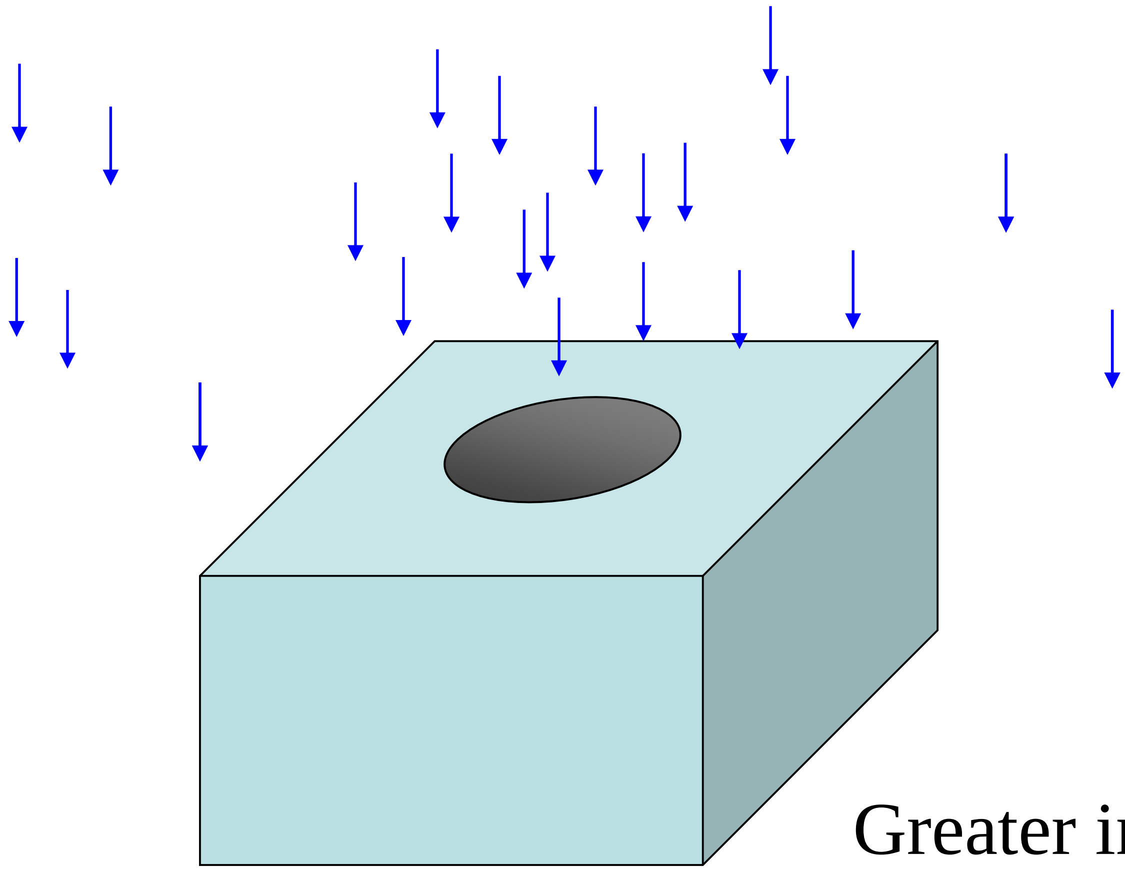

Greater intensity of rain results in more water collected.

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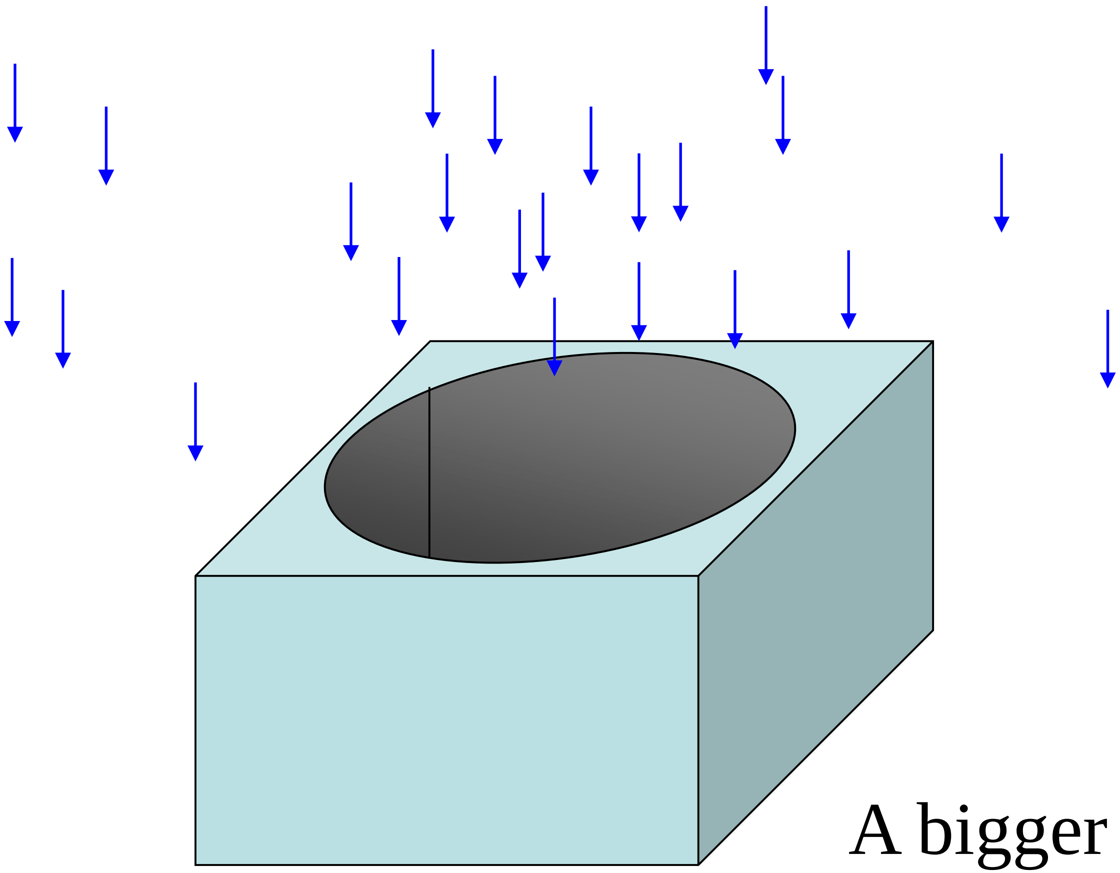
Suppose this box is left out in the rain. What will determine how much water it collects?



A bigger hole in the box results in more water collected.

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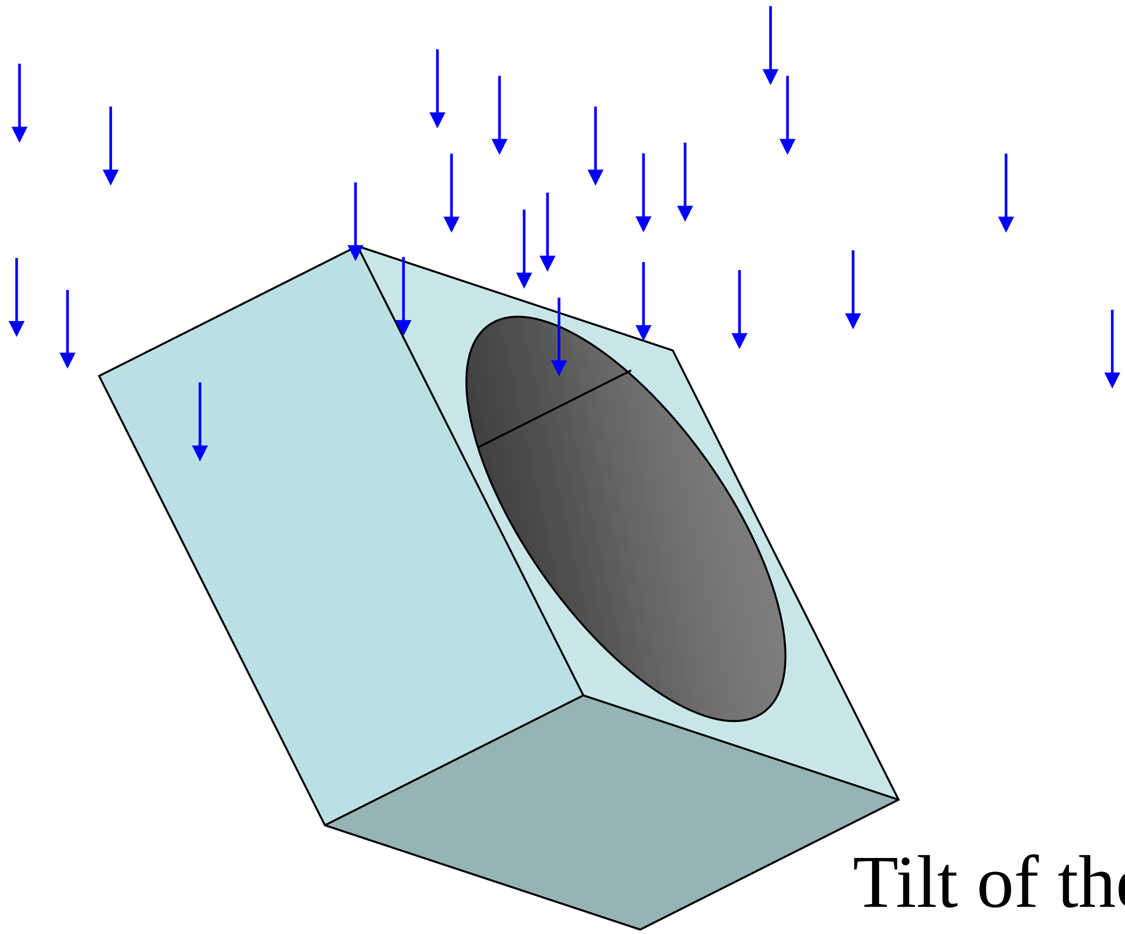
Suppose this box is left out in the rain. What will determine how much water it collects?



Tilt of the box results in less water collected.

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Suppose this box is left out in the rain. What will determine how much water it collects?

- Intensity of the rain (inches per second)
- Size of the hole – more specifically the **area** (square inches)
- Amount of time exposed to rain (seconds)
- Tilt of the hole

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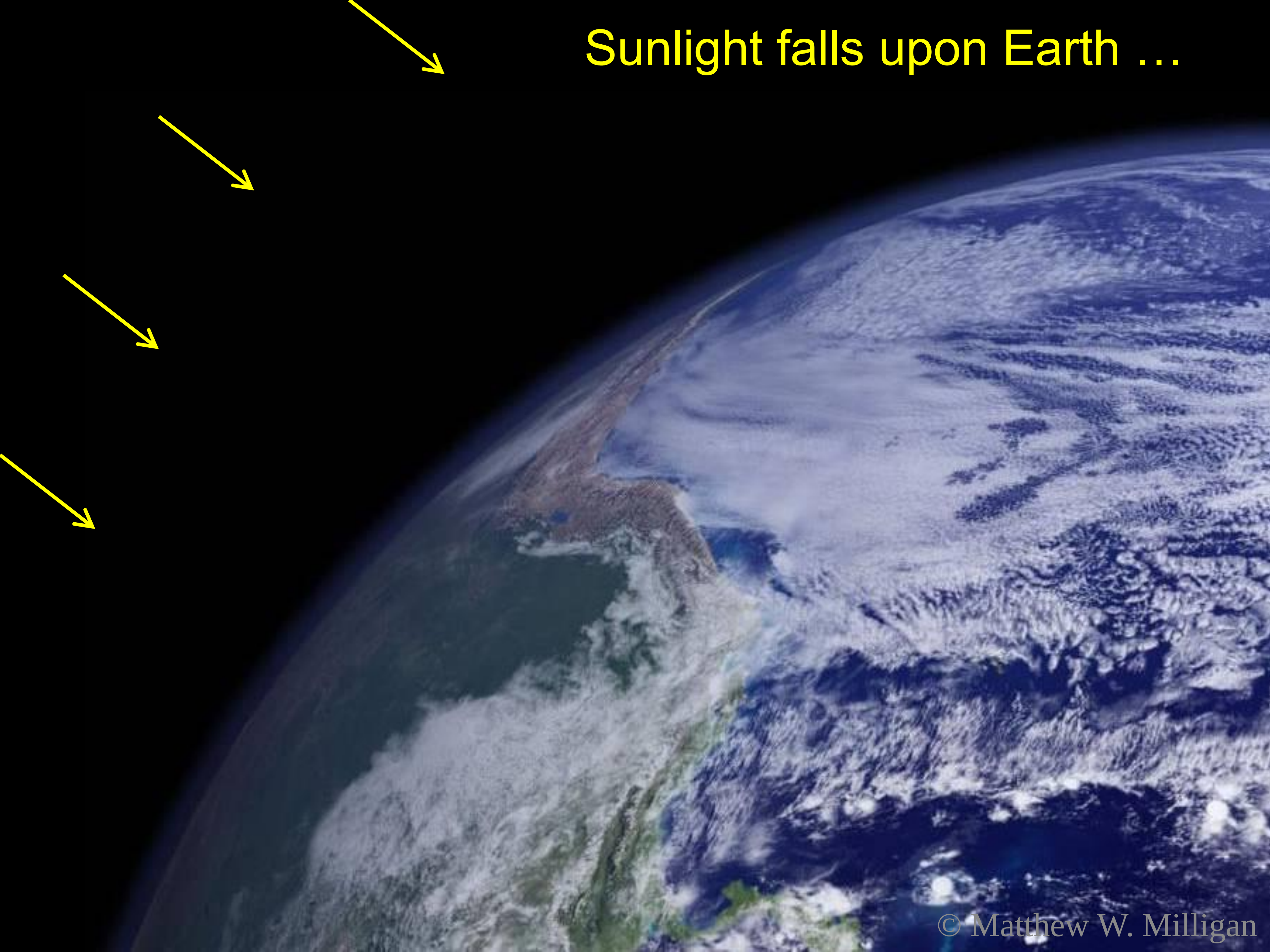
Sunlight falls upon Earth …
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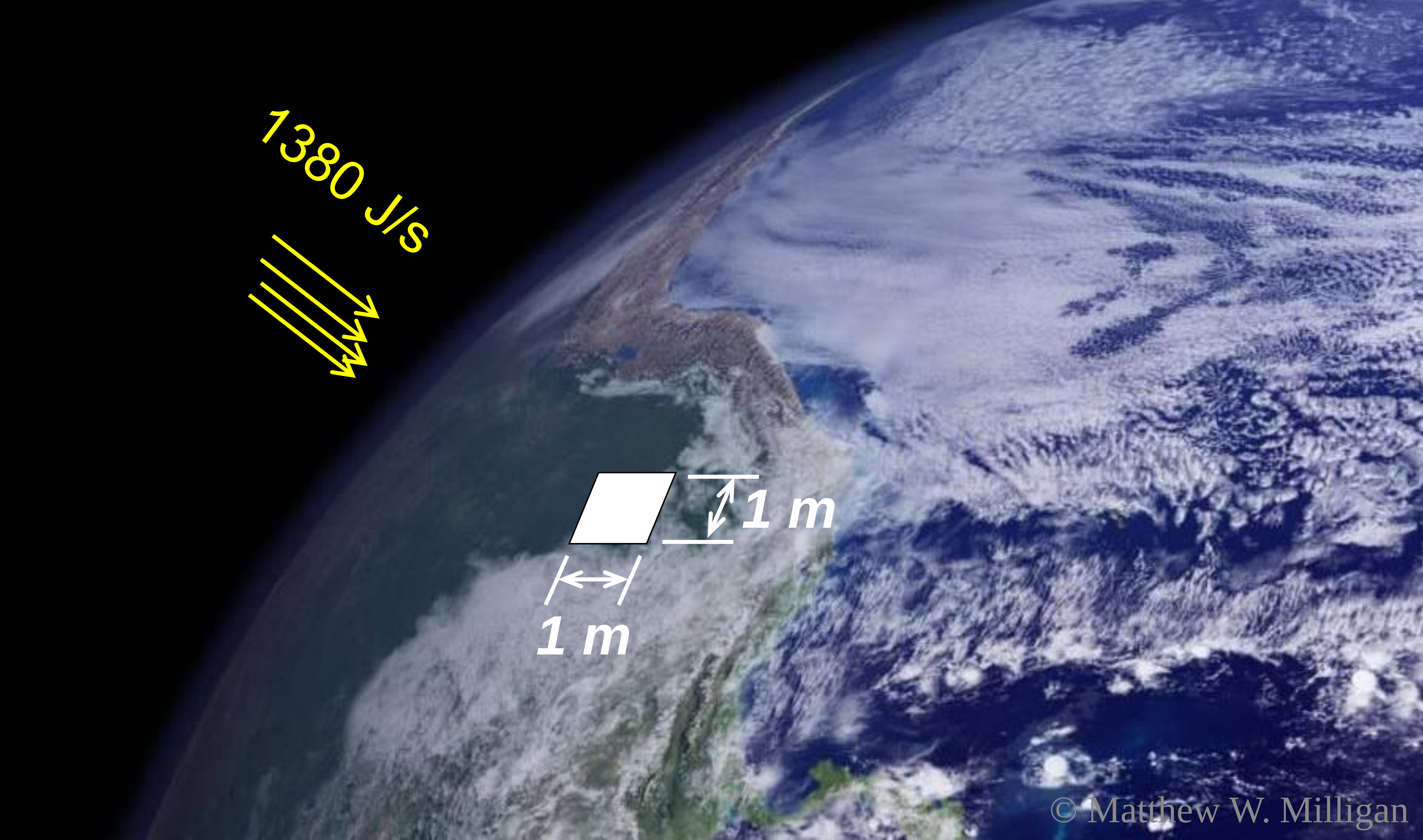
…but only 1380 joules of energy per second (at most) falls upon a single square meter. (This is called the **solar constant** or irradiance.)



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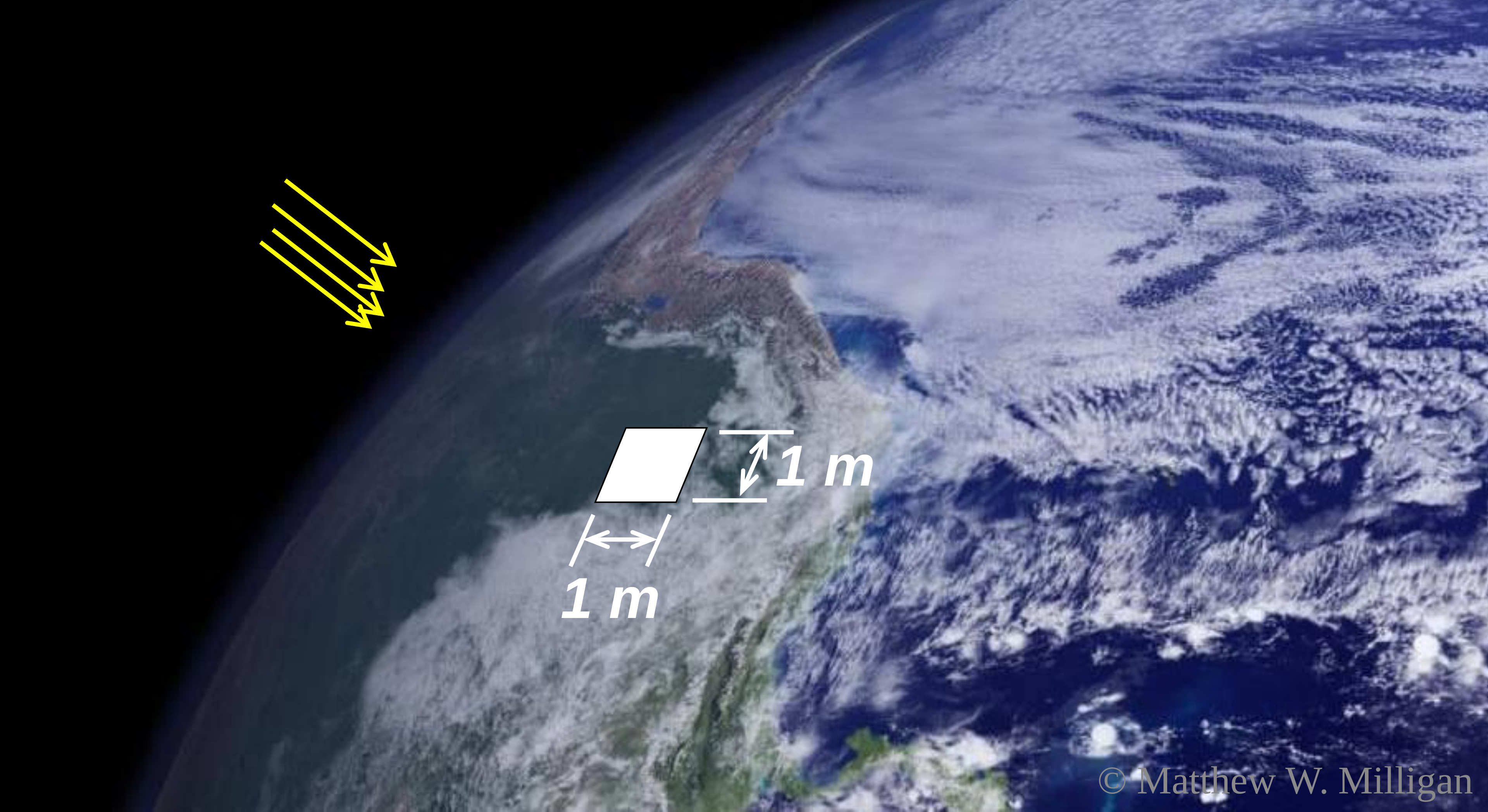
Therefore the intensity of sunlight can be represented by a value of 1380 W/m^2. Does energy absorbed by the surface of the Earth depend on latitude?



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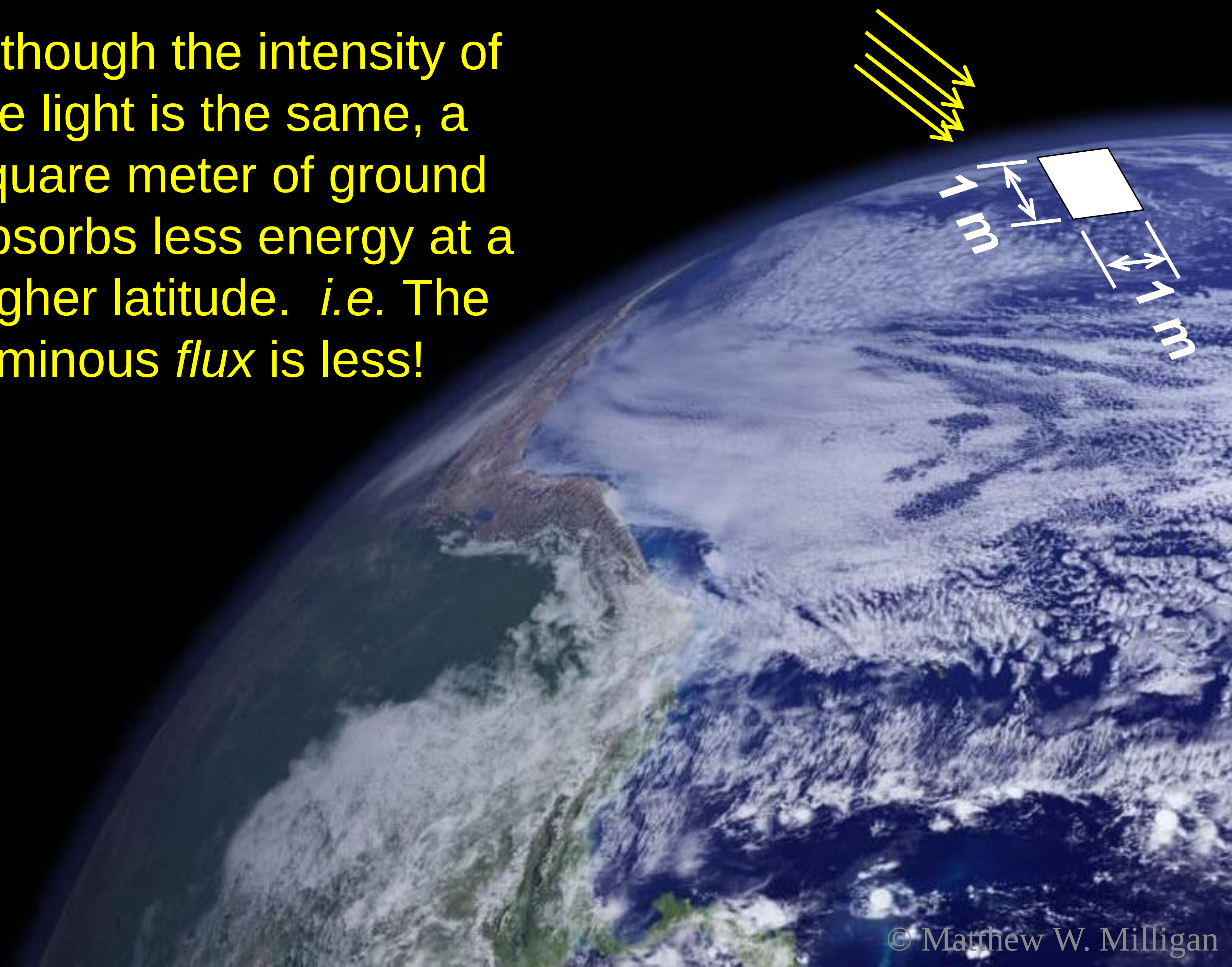
Although the intensity of the light is the same, a square meter of ground absorbs less energy at a higher latitude. *i.e.* The luminous *flux* is less!



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Flux

- In both the rain and light examples flux is dependent on the intensity – more intense rain or light increases the flux.
- In both cases the flux is dependent on area – greater area increases the flux.
- In both cases the flux is dependent on the orientation of the relevant area – being perpendicular to the flow maximizes flux.

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Electric Flux

- Electric flux is not a literal flow but rather a measure of the electric field “intercepting” a certain surface.
- The greater the intensity of the electric field, the greater the area of the surface, and the “more correctly aligned” (*i.e*. surface perpendicular to flow), the greater the electric flux.

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Electric Flux

$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

where: Φ_E = electric flux

E = electric field

A = area vector (normal to surface)

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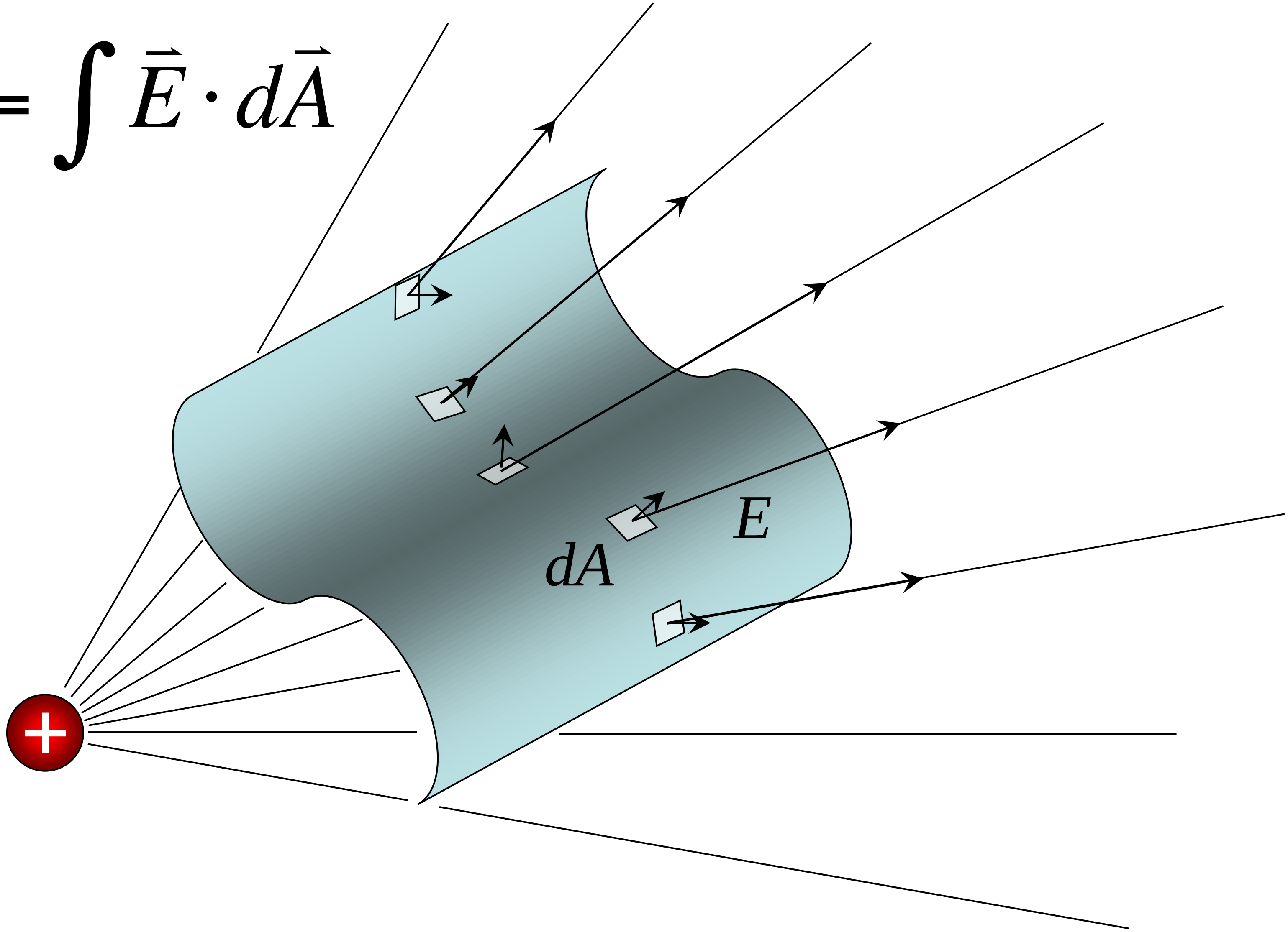
$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$



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Electric Flux

- Electric flux is a scalar quantity that may be positive or negative depending on the direction of the flow.
- The electric flux for a given surface is directly proportional to the number of electric field lines crossing through the surface.
- For a surface that encloses a volume – a closed surface – the area vector *dA* points outward (away from the inside) by convention.

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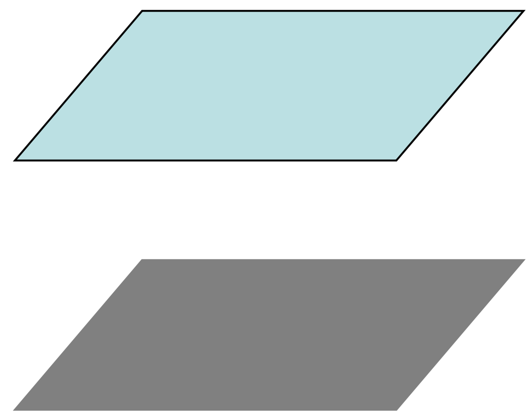
Understanding Dependence on Angle

Imagine sunlight shining down on a rectangle that rotates …



…the flux is proportional to the size of the shadow.

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Understanding Dependence on Angle

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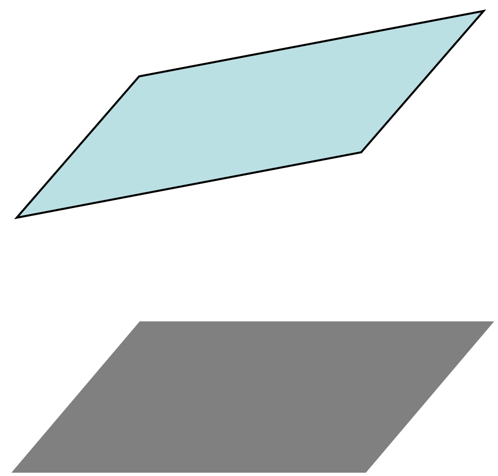

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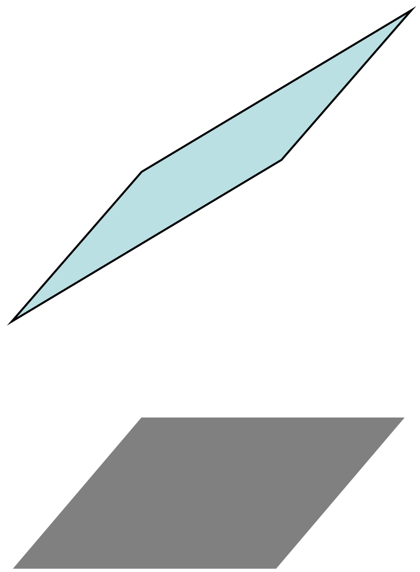

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Understanding Dependence on Angle

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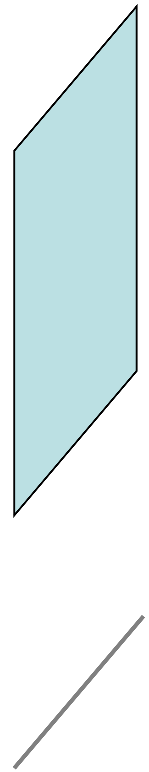

…the flux is proportional to the size of the shadow.

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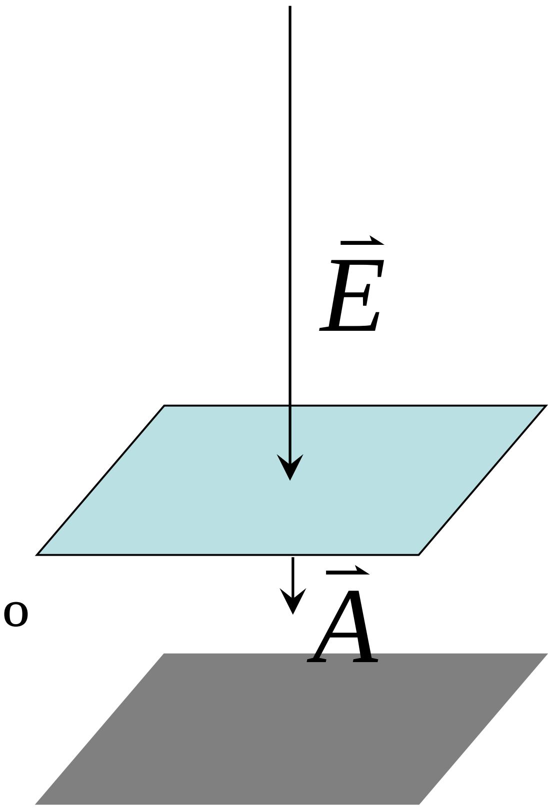
If field E is uniform and rectangle has area A, then:

$$\Phi_E = \vec{E} \cdot \vec{A}$$

$$\Phi_E = EA\cos\theta$$



$\theta = 0^{o}$

$$\Phi_E = EA$$

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If field *E* is uniform and rectangle has area *A*, then:

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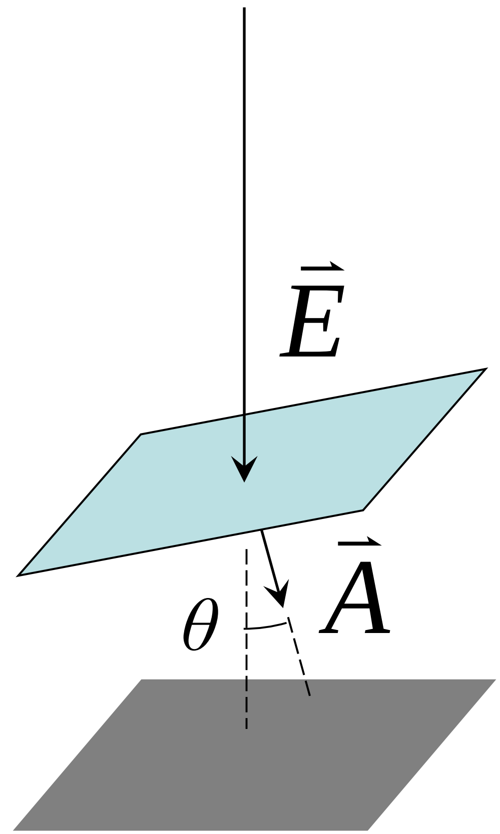

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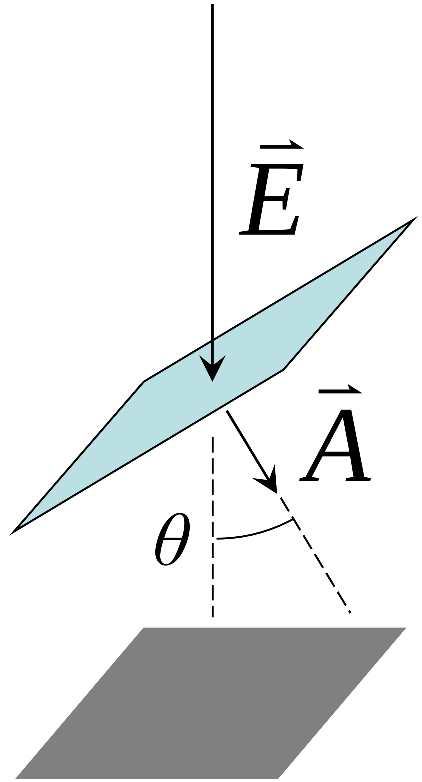

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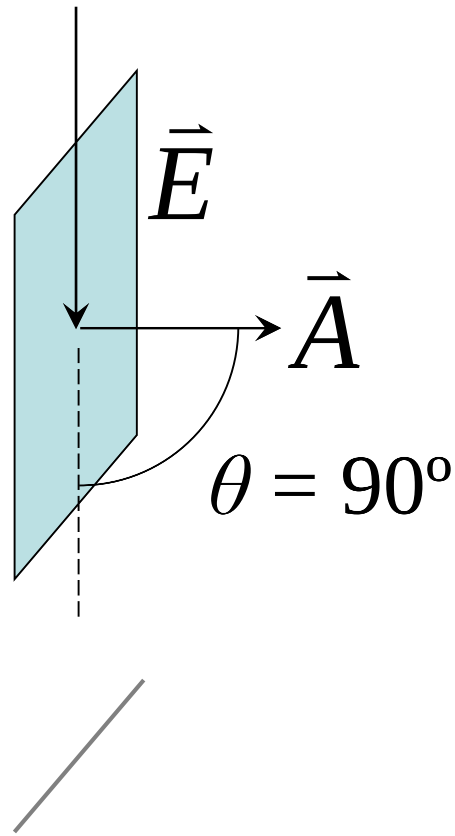

$$\Phi_E = 0$$

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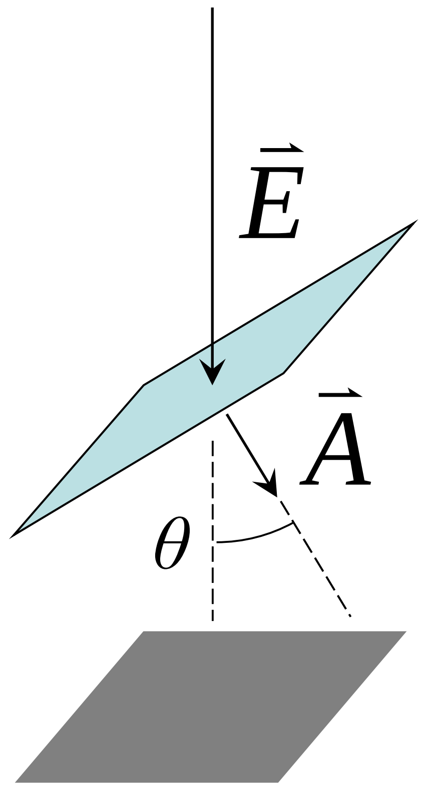
If field E is uniform and rectangle has area A, then:

$$\Phi_E = \vec{E} \cdot \vec{A}$$

$$\Phi_E = EA\cos\theta$$

This is always equal to the area of the "shadow".



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