

Fundamentals of Light: Illumination



تم تحميل هذا الملف من موقع المناهج الإماراتية

موقع المناهج ← المناهج الإماراتية ← الصف التاسع المتقدم ← فيزياء ← الفصل الثالث ← ملفات متنوعة ← الملف

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المزيد من مادة
فيزياء:

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التواصل الاجتماعي بحسب الصف التاسع المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف التاسع المتقدم والمادة فيزياء في الفصل الثالث

هيكل امتحان أوراق عمل الموجات

1

بريدج شرح هيكل الامتحان أسئلة تدريبية

2

بريدج هيكل الامتحان أسئلة تدريبية

3

Physics Inspire - Mechanical Waves

4

ملف أسئلة Inspire وفق الهيكل

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MODULE 15

FUNDAMENTALS OF LIGHT

LESSON 1

ILLUMINATION

What Is **Light**?

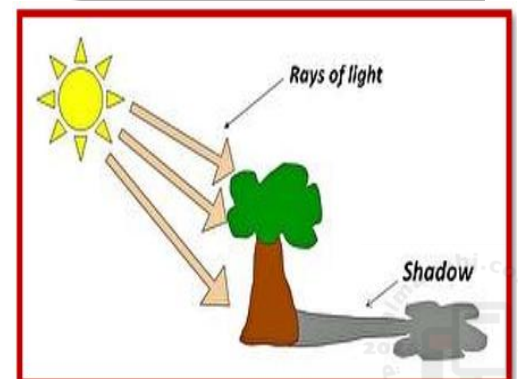
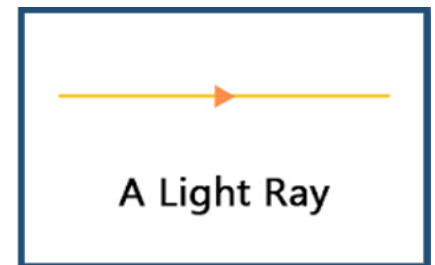
- Light is **electromagnetic radiation**, like radio and microwaves.
- Can be modeled as a **wave** of changing electric and magnetic fields or as **particles called photons**.
- **Wave model** explains many features of electromagnetic radiation.
- **Particle model** explains other features.
- Module covers **wave properties of light**; photons discussed in later module.

Light's Path

- Sight depends on **light from surroundings reaching your eyes**.
- Narrow beams of light (flashlight, sunlight through window) made visible by **dust particles**.
- Light travels in a **straight line**.
- Shadows form when your body blocks sunlight, showing **outline**.

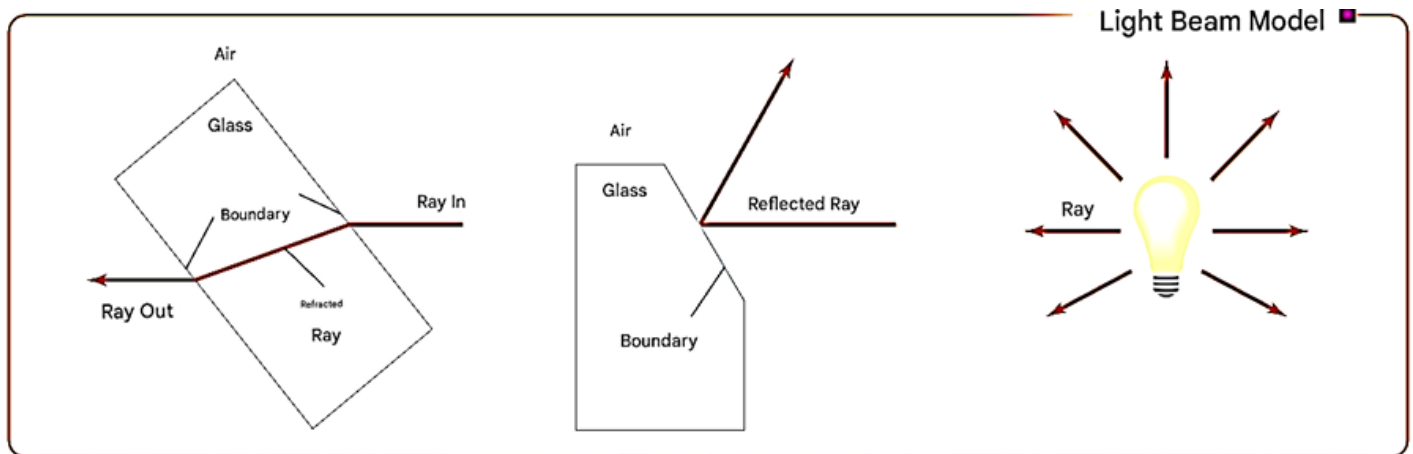


Figure 1 Light rays traveling in straight lines are evident in many situations.



Ray Model of Light

Light always travels in **straight lines**, and when it reaches a boundary, its direction can change either by **reflection** or **refraction**. Even after interacting with a boundary, the ray continues moving in a straight path but in a new direction. These basic principles form what is called the **ray model of light**, and the study of such interactions is known as ray optics or geometric optics.



Sources of light

Luminous sources

- The object produce and emits its own light.

Illuminated sources

- The object that light reflect by them.

Include

Natural sources

Examples:-

- Sun.
- Flames.
- Fireflies.

Human_made devices

Examples:-

- T.V screen.
- Computers monitors.
- Lasers.
- Tiny, light emitted diodes.

- The sources, which is visible because it reflects the light.
- These objects we can't see without light.

Examples:-

- The moon.
- All objects except luminous sources.

Types of mediums

Materials are divided **into three types** according to the properties of light:

Type	Definition	Examples
(Opaque)	• Absorbs or reflects most light • doesn't allow light through	Books, walls, humans, metals, bags
(Translucent)	• Transmits light but scatters it • unclear visibility	Stained glass, frosted glass, wax paper
(Transparent)	• Transmits most light • allows clear visibility • reflects a little	Clear glass, air, pure water

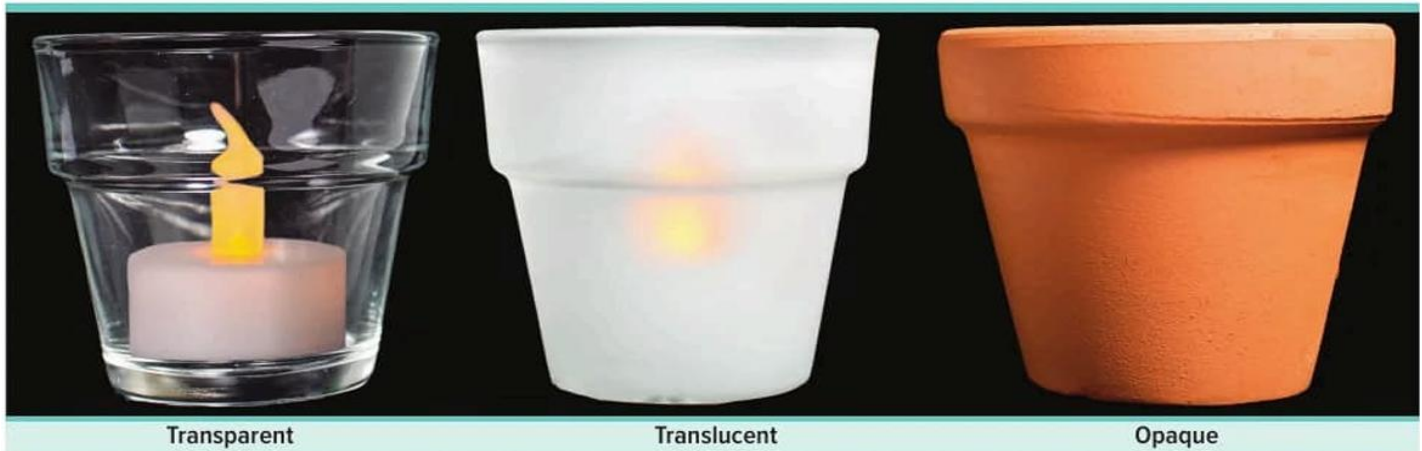


Figure 4 Light is transmitted through the transparent and translucent candle holders. The candle cannot be seen clearly in the opaque holder because the light is absorbed.

Important Note: All types of materials absorb some light, but opaque ones absorb the most.

Why Do We See the Fish and the Aquarium Glass?

- We see the fish because the transparent glass allows light to pass through, so the reflected light from the fish reaches our eyes.
- We see the glass itself because, although it is transparent, it reflects a small amount of light toward our eyes.

MULTIPLE CHOICE

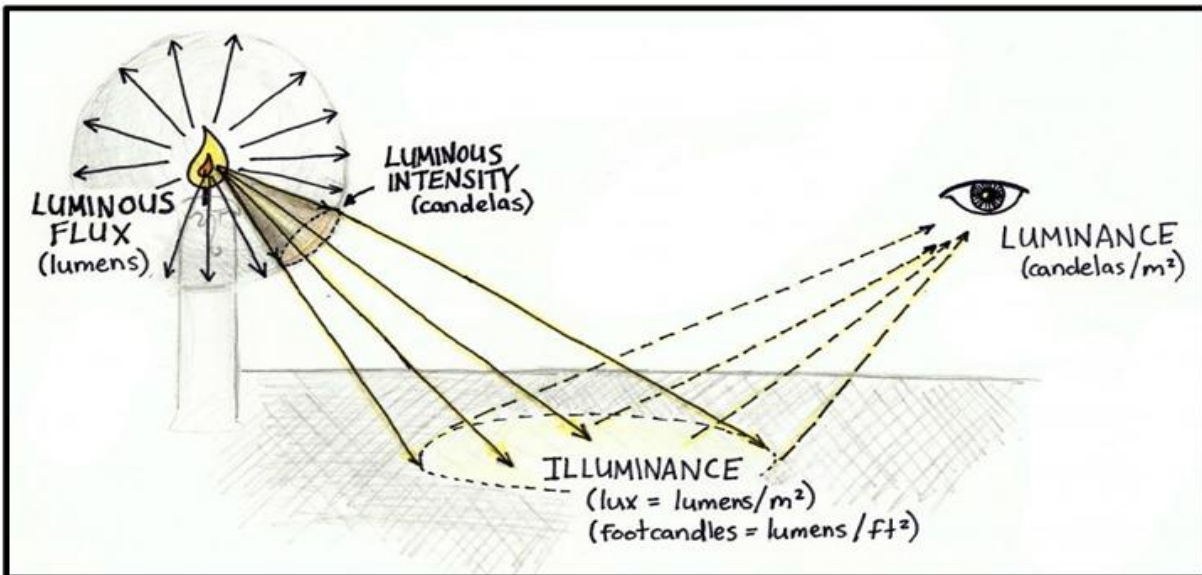
- 1- **Define the light?**
A. Electric conduction B. Electric waves
C. Longitudinal waves D. Electromagnetic radiation
- 2- The object that reflect the light :
A. Lazer B. Computers C. Sun D. Building surface
- 3- Which one is **Luminous sources of light** :
A. Moon B. Sun C. Lazer D. Fireflies E. B+C+D
- 4- Which of the following is an example of an opaque medium?
A. Glass B. Frosted glass C. Vacuum D. woods
- 5- Which media if light can transmit most light :
A. Opaque Material B. Translucent Material C. Transparent Material D. All of them
- 6- When does light no longer travel in a straight line?
A. When it loses power
B. When there is electrical interference
C. When it hits a boundary
D. When there is magnetic interference
- 7- Windows in a home usually give a clear view of what is outside. Which term describes this type of window?
A. Opaque C. Translucent
B. Transparent D. Reflector

Quantity Of Light

There are three factors that determine the brightness of light, which are:

1. Quantity of light the source produces.
2. Distance between the source and the eye.
3. Angle at which light enters the eye.

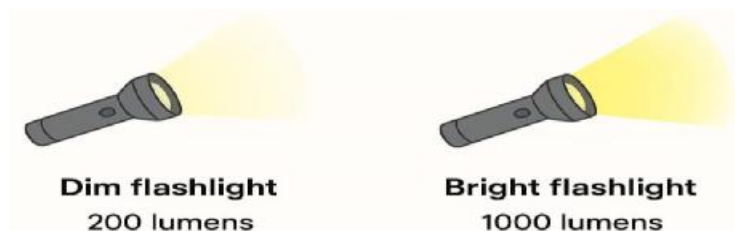
Brightness: Refers to how intense or strong the light appears to the human eye.



Luminous Flux (P):

- The rate at which a light source produces light energy.
- Unit: lumen (lm).
- Brighter sources emit more light rays in all directions than dimmer sources.
- The total light striking a surface depends only on the luminous flux of the source.

What does it measure? It measures the strength or intensity of the light source itself



- The sphere around the lightbulb shows that light spreads out in every direction.
- To measure all the light produced, we imagine a closed surface (sphere) around the source.
- The total light energy emitted per second is called luminous flux (P), measured in lumens (lm).

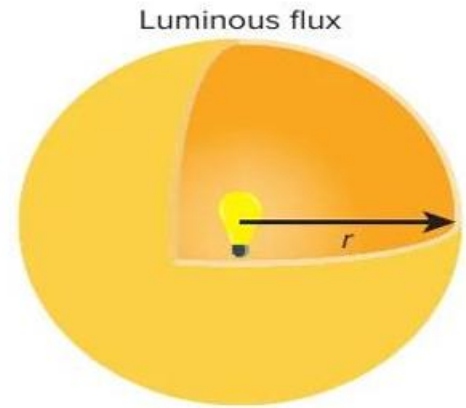


Figure 5 Luminous flux is the rate at which light rays are emitted from a luminous source.

Illuminance (E):

What is illumination?

- It is the amount of light (**luminous flux**) falling on a specific area of a surface at a given moment.
- In simpler terms: It is the "**luminosity**" or "brightness" of a specific spot on a surface.
- Unit: It is measured in lux (**lx**) or lumens per square meter (**lm/m²**). (**1 lx = 1 lm/m²**)

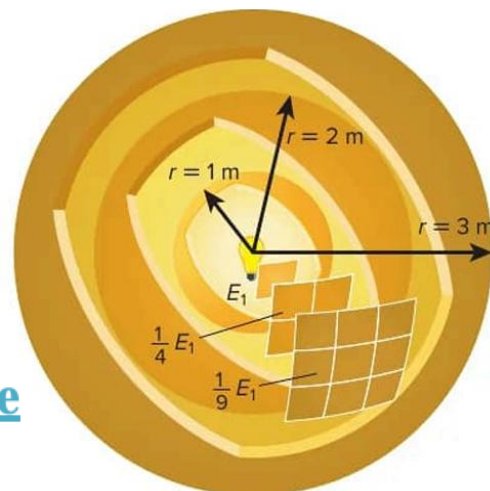
Illuminance and inverse square relationship:

If you have a lamp that emits a fixed amount of light (lumens), that light spreads out in all directions. The further you are from the lamp, the more that light spreads out over a larger area, meaning the amount of light reaching each square meter (illuminance) decreases.

$$E = \frac{P}{4\pi r^2}$$

r : the distance between the object and the light source.

4πr²: Surface Area of a Sphere



Illuminance

$$E_1 = \frac{1750}{4\pi} \text{ lx}$$

$$E_2 = \frac{1750}{4\pi 2^2} \text{ lx}$$

$$E_3 = \frac{1750}{4\pi 3^2} \text{ lx}$$

Inverse-Square relationship:

- When light spreads out from a point source, it travels in straight lines in all directions.
- As the distance from the source increases, the same amount of light is spread over a larger area.
- This means the illuminance (E) decreases with the square of the distance (r):

$$E \propto \frac{1}{r^2}$$

- Example:
 - At 1 m → full brightness (100%).
 - At 2 m → only 1/4 of the brightness.
 - At 3 m → only 1/9 of the brightness.

✨ This law explains why stars look dim from Earth even though they are extremely luminous.

ملاحظات مهمة

✓ تتناسب الأستضاءة (E) تناسباً **طردياً** مع مقدار التدفق الضوئي (P).

Illuminance (E) is **directly proportional** to the amount of luminous flux (P).

✓ تتناسب الأستضاءة (E) تناسباً **عكسياً** مع مقدار مساحة السطح (A).

Illuminance (E) is **inversely proportional** to the surface area (A).

✓ تتناسب الأستضاءة (E) تناسباً **عكسياً** مع مربع نصف القطر ($r = \pi r^2$).

Illuminance (E) is **inversely proportional** to the square of the radius ($r = \pi r^2$).

Luminous Intensity:

- Luminous intensity (I) is measured in candelas (cd).
- A candela is not the measure of total luminous flux, but the flux per unit solid angle in a specific direction.
- For a point source, the luminous intensity = luminous flux that falls on 1 m² of the inside of a sphere with radius 1 m.

$$I = \frac{P}{4\pi}$$

P: Luminous Flux (lm)

I: Luminous Intensity (Cd)

There is a relationship **between light intensity and illumination** through the following relationship:

$$E = \frac{I}{r^2}$$

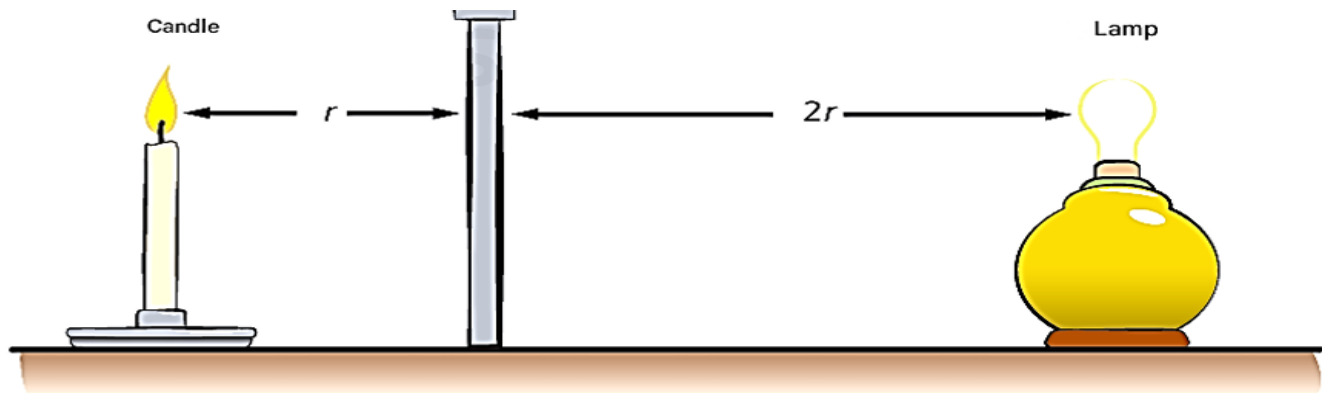
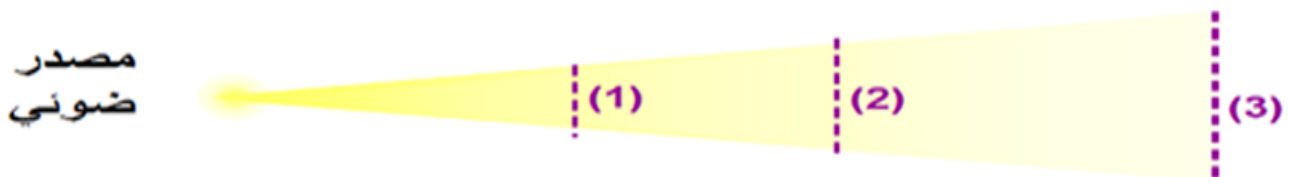


Figure 7: For the surface of the barrier facing the candle to be illuminated, the light intensity of the lamp must be four times that of the candle.



The luminous flux in the three regions is **equal**
The illuminance in the three regions is **different**

Surface Illumination

- Illumination depends on luminous intensity, luminous flux, and distance.
- Brighter bulb → more luminous flux.
- shorter distance → stronger illumination.
- Engineers design lighting to avoid dark areas by spacing lights evenly.
- Special optics help spread light uniformly.
- Critical for car headlights: wrong angles cause dark spots on road.

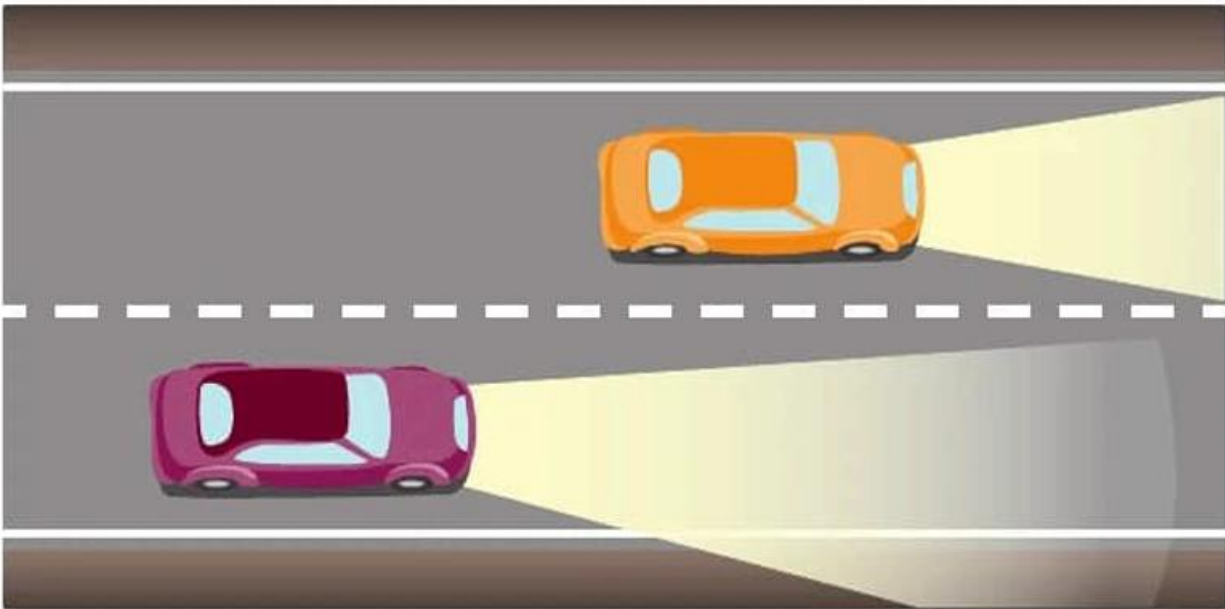
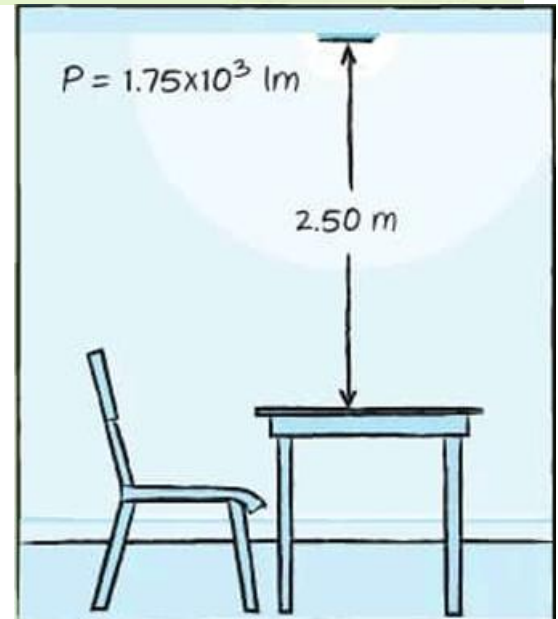


Figure 8 Dark areas can occur if headlights on cars are not set at the correct angles to adequately illuminate the road.

Quantity	Symbol	Definition	Unit	Symbol
Luminous flux	Φ	The rate at which a luminous source produces light energy.	Lumen	lm
Illuminance	E	The luminous flux falling on a given surface area at any instant.	lux	$\text{lx} = \text{lm}/\text{m}^2$
Luminous intensity	I_v	The luminous flux that falls on 1 m^2 of the inside of a 1 –m- radius sphere.	candela	cd

EXAMPLE Problem 1

ILLUMINATION OF A SURFACE What is the illuminance on your desktop if it is lit by a 1750-lm lamp that is 2.50 m above your desk?

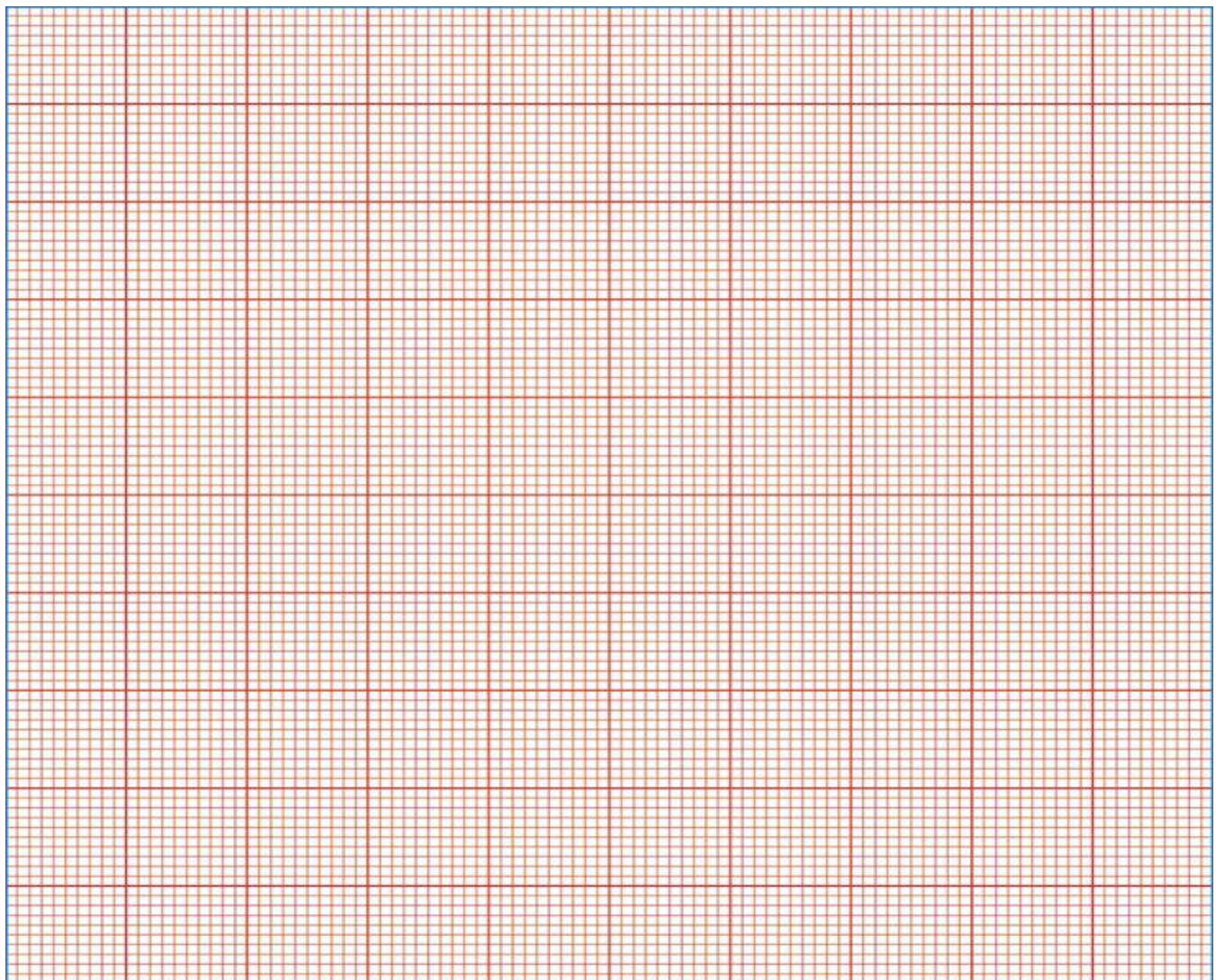


1. A lamp is moved from 30 cm to 90 cm above the pages of a book. Compare the illumination on the book before and after the lamp is moved.



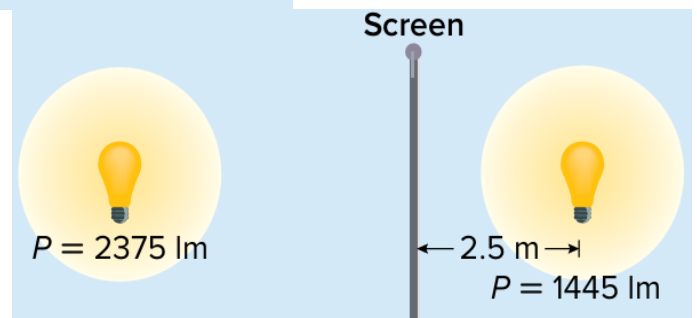
2. Draw a graph of the illuminance produced by a lamp with a luminous flux of 2275 lm at distances from 0.50 m and 5.0 m.

r(m)	0.5	0.75	1.0	1.25	1.50	1.75	2.0	2.25	2.5	2.75	3.0	3.5	4.0	4.5	5.00
E(Lx)															



3. A 64-cd point source of light is 3.0 m away from a painting. What is the illumination on the painting in lux?

4. A screen is placed between two lamps so that they illuminate the screen equally, as shown in **Figure 9**. The first lamp emits a luminous flux of 1445 lm and is 2.5 m from the screen. What is the distance of the second lamp from the screen if the luminous flux is 2375 lm?



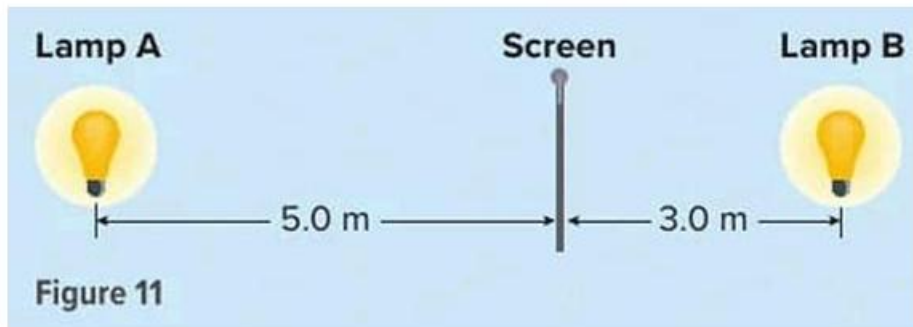
5. What is the illumination on a surface that is 3.0 m below a 150-W incandescent lamp that emits a luminous flux of 2275 lm?

6. A public school law requires a minimum illuminance of 160 lx at the surface of each student's desk. An architect's specifications call for classroom lights to be located 2.0 m above the desks. What is the minimum luminous flux that the lights must produce?

7. CHALLENGE Your local public library is planning to remodel the computer lab. The contractors have purchased fluorescent lamps with a rated luminous flux of 1750 lm. The desired illumination on the keyboard surfaces is 175 lx. Assume a single lamp illuminates each keyboard. What distance above the surface should the lights be placed to achieve the desired illumination? If the contractors had also already purchased fixtures to hold the lights that when installed would be 1.5 m above the keyboard surface, would the desired illuminance be achieved? If not, would the illuminance be greater or less than desired? What change in the lamp's luminous flux would be required to achieve the desired illuminance?

Two lamps illuminate a screen equally from distances shown in Figure 11.

If Lamp A is rated 75 cd, what is Lamp B rated?



The speed of light

Measuring the speed of light was a very difficult task.

The scientist Roemer was able to measure the time required for light to travel from a point on the **Earth's surface to the planet Jupiter**.

استطاع العالم رومر (Roemer) قياس الزمن اللازم لانتقال الضوء من نقطة على سطح الأرض للكوكب المشتري.

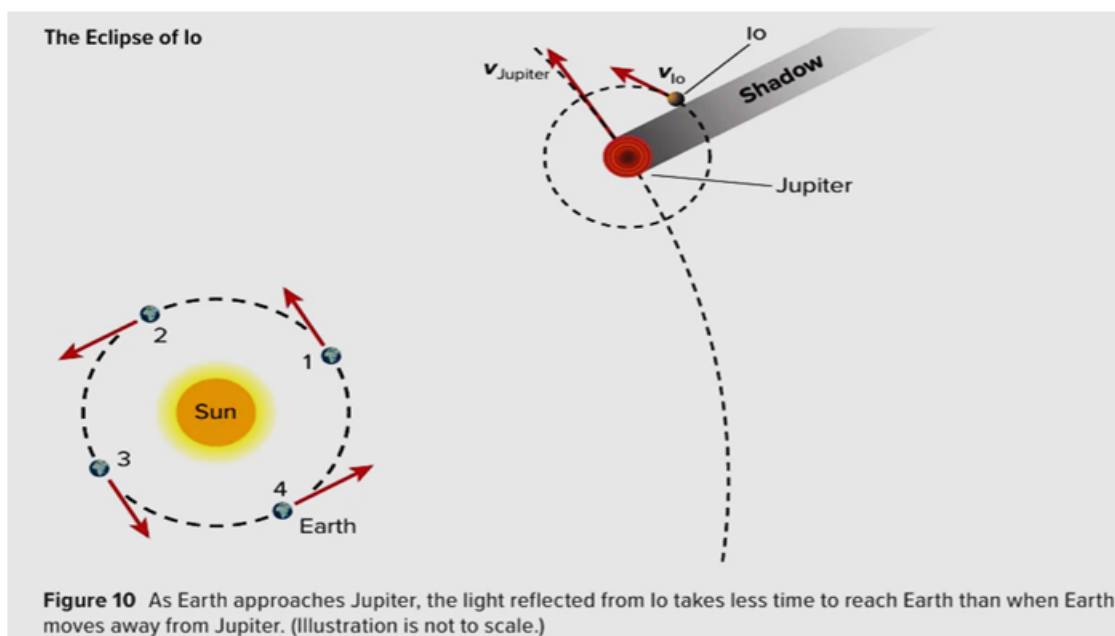
Römer noticed that the time required for light to reach Jupiter changes with the position of the Earth, and thus the speed of light changes from one place to another.

لاحظ رومر ان الزمن اللازم لوصول الضوء الى المشتري تتغير بتغير موضع الكره الأرضية فبتالي تتغير سرعة الضوء من مكان لآخر.

Römer concluded that the speed of light is **limited**, ranging from $(2.2 \times 10^8 \text{ m/s})$ to $(3 \times 10^8 \text{ m/s})$.

استنتج رومر أن سرعة الضوء محدودة تتراوح ما بين $(2.2 \times 10^8 \text{ m/s})$ الى $(3 \times 10^8 \text{ m/s})$

- This was the first experimental evidence proving that light has a finite speed.



Michelson's experiment:

- Between **1880 and the 1920s**, American physicist **Albert A. Michelson** developed Earth-based techniques to measure the speed of light.
- His method was based on **measuring the time it took light to make a round trip** between two California mountains separated by about **35 km**.
- He used a system of **rotating mirrors** to reflect the light beam and accurately determine the time interval.
- His best result was:

$$(2.99796 \pm 0.00004) \times 10^8 \text{ m/s}$$

- This was the most precise measurement of the speed of light at that time.
- For this achievement, Michelson became the **first American to receive the Nobel Prize in Physics (1926)**.
- At this speed, light travels 9.46×10^{12} km in a year. This amount of distance is called a light-year.

Multiple Choice Questions About Measuring the Speed of Light:

What did Ole Rømer prove in the 17th century?

- a) The speed of light is infinite
- b) The speed of light is slower than the speed of sound
- c) The speed of light is finite
- d) Light requires no time to travel

How did Rømer measure the speed of light?

- a) Using rotating mirrors
- b) By studying the eclipses of Jupiter's moon "Io"
- c) By measuring the time it takes light to travel between two mountains
- d) By calculating the distance of a light-year

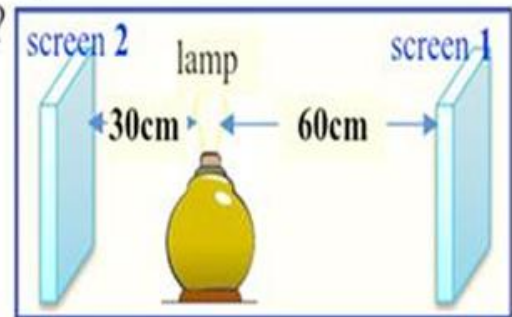
What distance does light travel in one year?

- a) 9.46×10^{12} km
- b) 3.0×10^8 km
- c) 299,792 km
- d) 35 km

In the figure , if the illumination on screen 2 is (100 lm/m^2) ,
what is the illumination on screen 1 from the same source?

في الشكل المجاور إذا كانت استضاءة الشاشة 2 (100 lm/m^2)

ما استضاءة الشاشة 1 من المصباح نفسه ؟



100 lm/m^2

25 lm/m^2

400 lm/m^2

200 lm/m^2