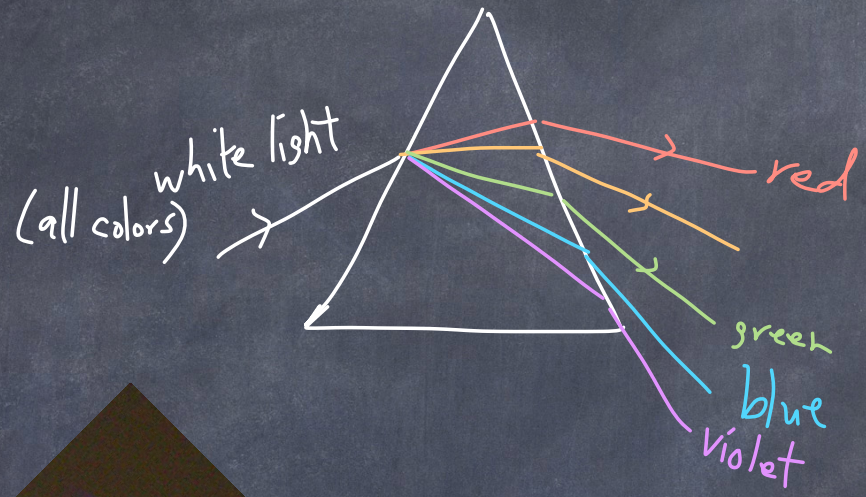
"I have set my rainbow in the clouds"
we add: "and it shall be at 42° with respect to you and the sun due to refraction and geometry..."

Also today: Creating light from darkness

PHY117 HS2023

Week 13, Lecture 1
Dec. 12th, 2023
Prof. Ben Kilminster

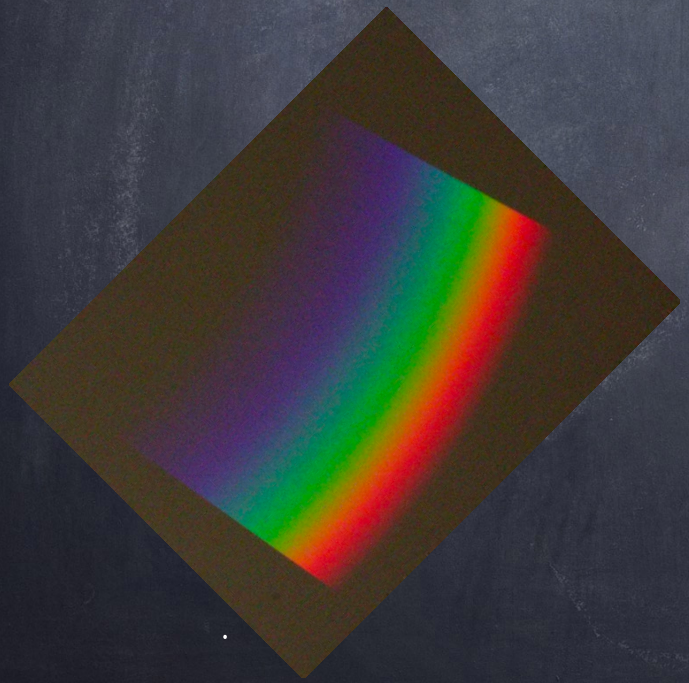
In addition) The index of refraction, n, depends slightly on the wavelength of the light



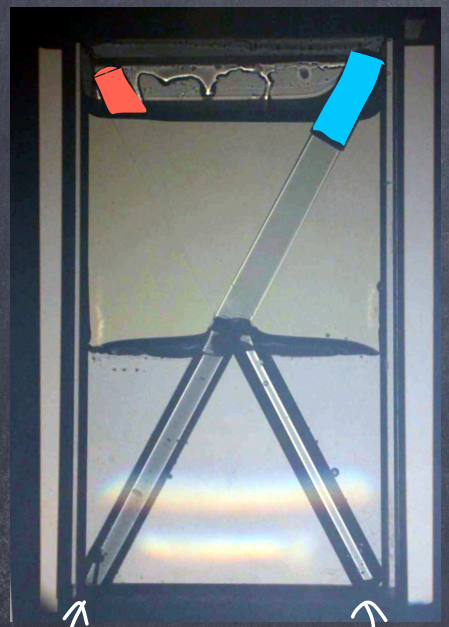
(exaggerated)

Short wavelength is bent more

blue bent more than red



$n_1 = n_2$ for one of the glasses

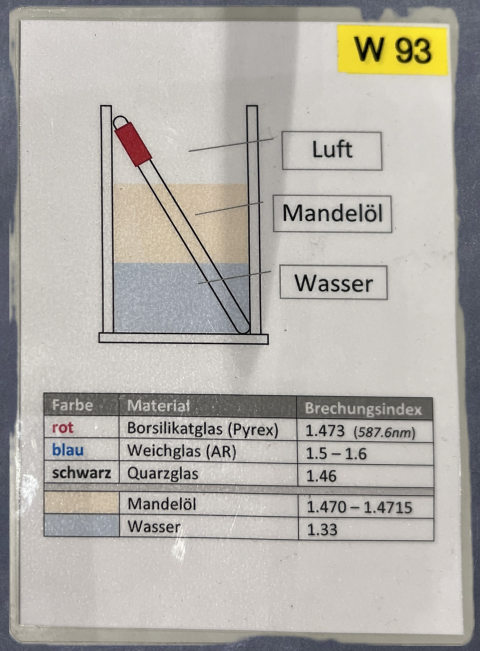


oil

water

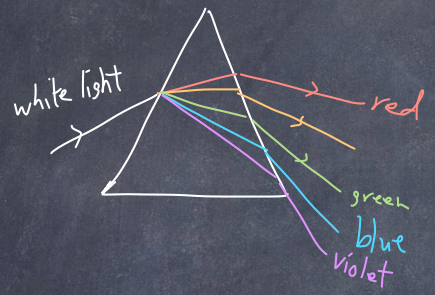
glass one

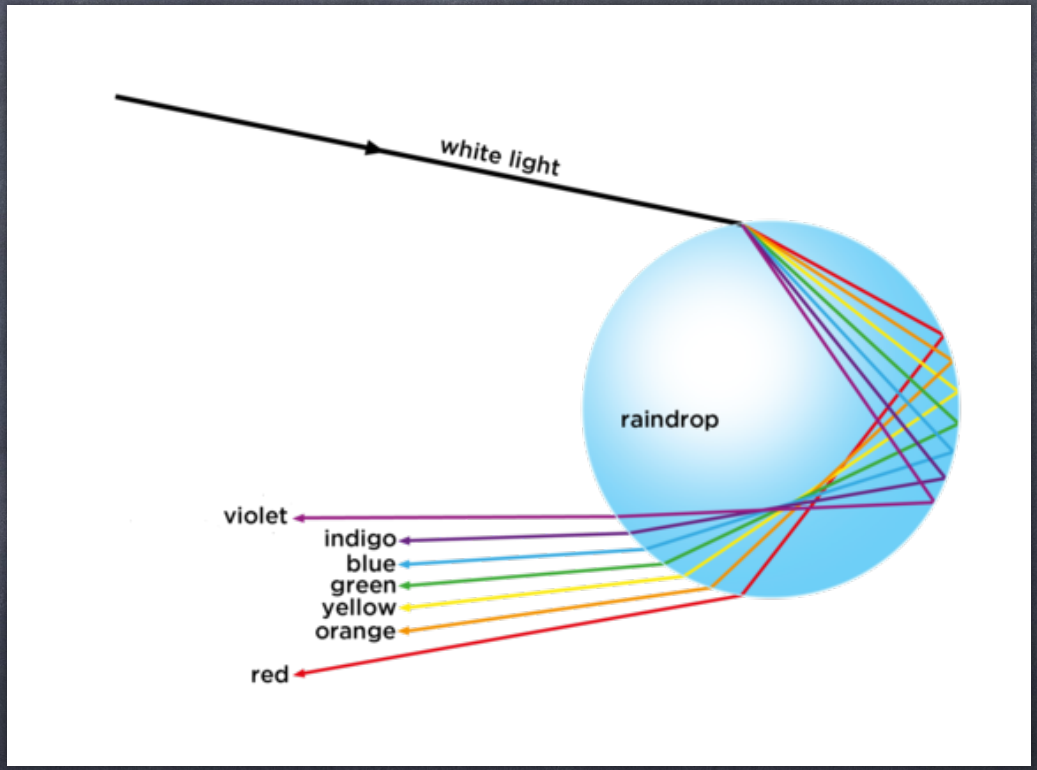
glass two



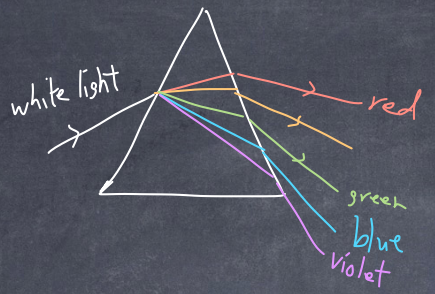
Farbe	Material	Brechungsindex
rot	Borsilikatglas (Pyrex)	1.473 (587.6nm)
blau	Weichglas (AR)	1.5 – 1.6
schwarz	Quarzglas	1.46
	Mandelöl	1.470 – 1.4715
	Wasser	1.33

Light through a rain drop

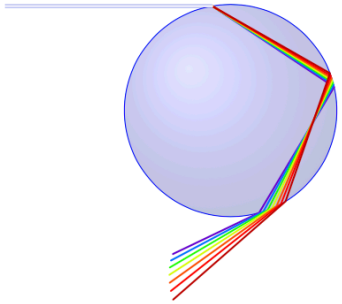




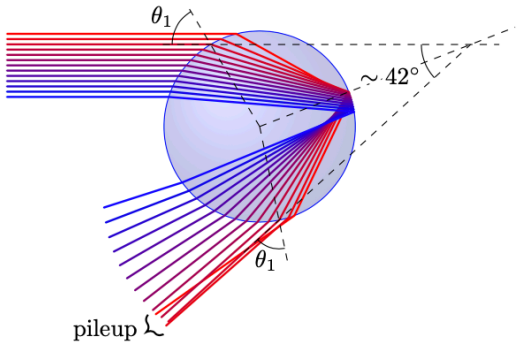
Pyramid:



water droplet sphere:

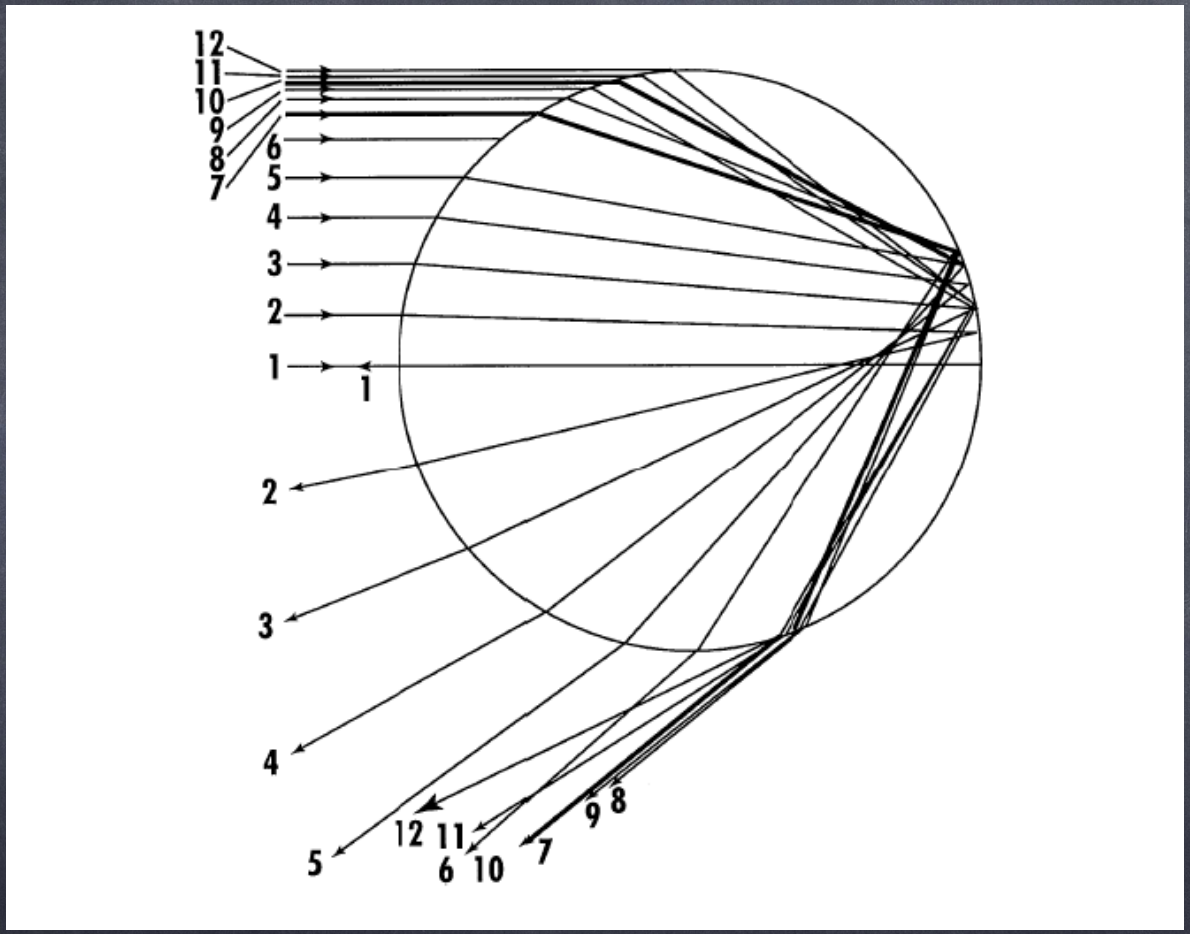


(a) A white light beam is spread in a rainbow due to dispersion (not to scale).



(b) At an effective reflection angle of about 42°, light is more concentrated (color unrelated to wavelength).

Figure 14.6: Explaining rainbows with dispersion and internal reflection in water droplets.


12
11
10
9
8
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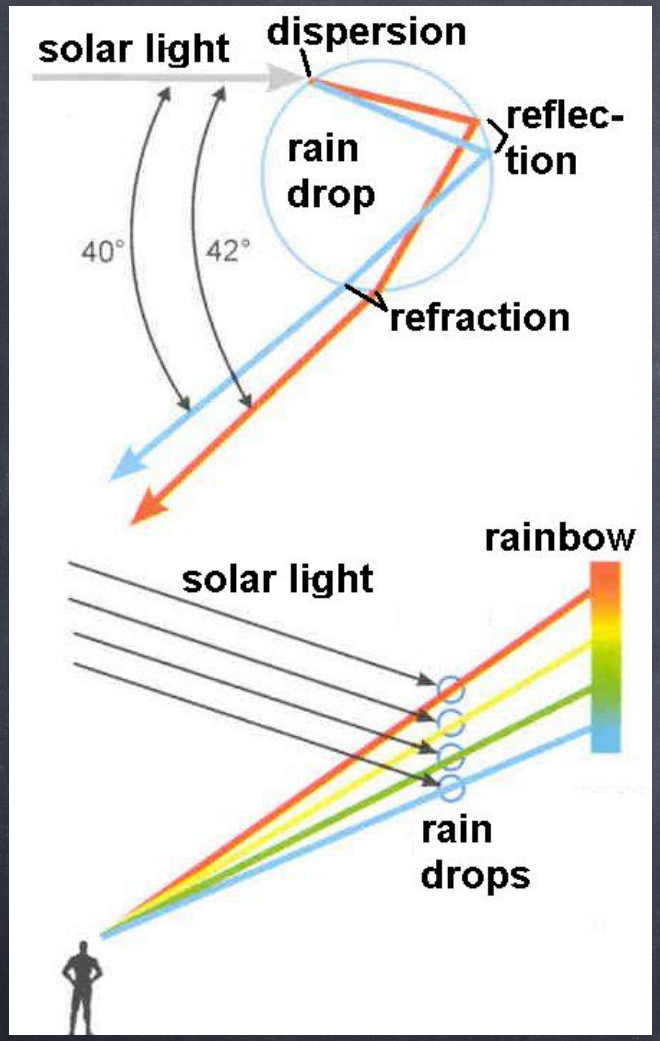
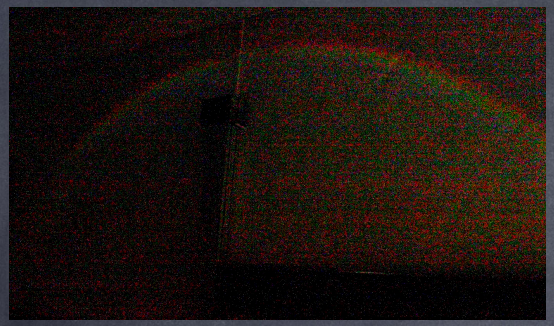
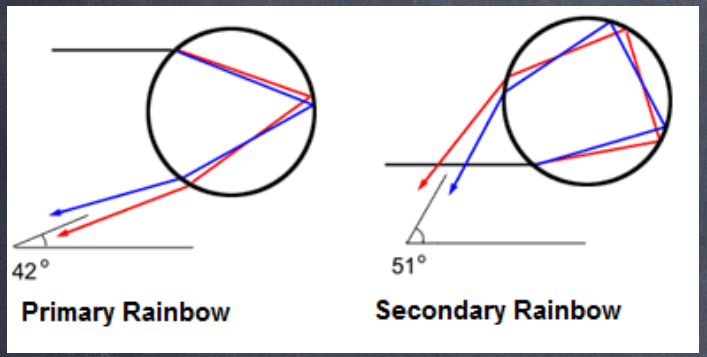
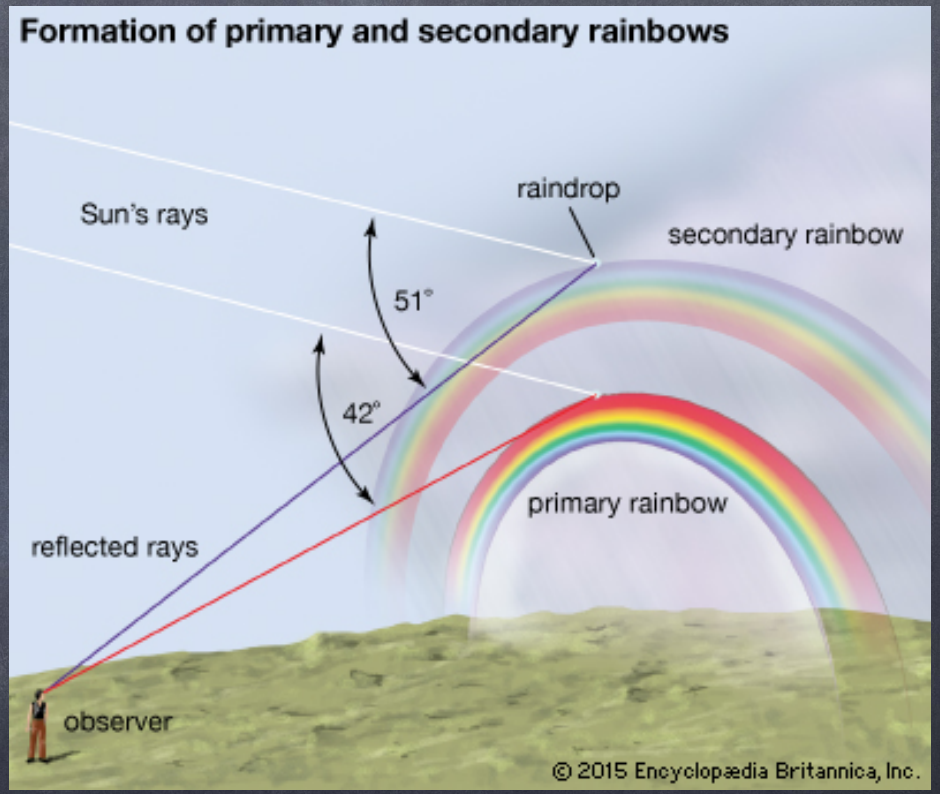

solar light
dispersion
reflec-
tion
rain
drop
40°
42°
refraction
rainbow
solar light
rain
drops




42°
51°
Primary Rainbow
Secondary Rainbow


Formation of primary and secondary rainbows
Sun's rays
raindrop
secondary rainbow
51°
42°
primary rainbow
reflected rays
observer
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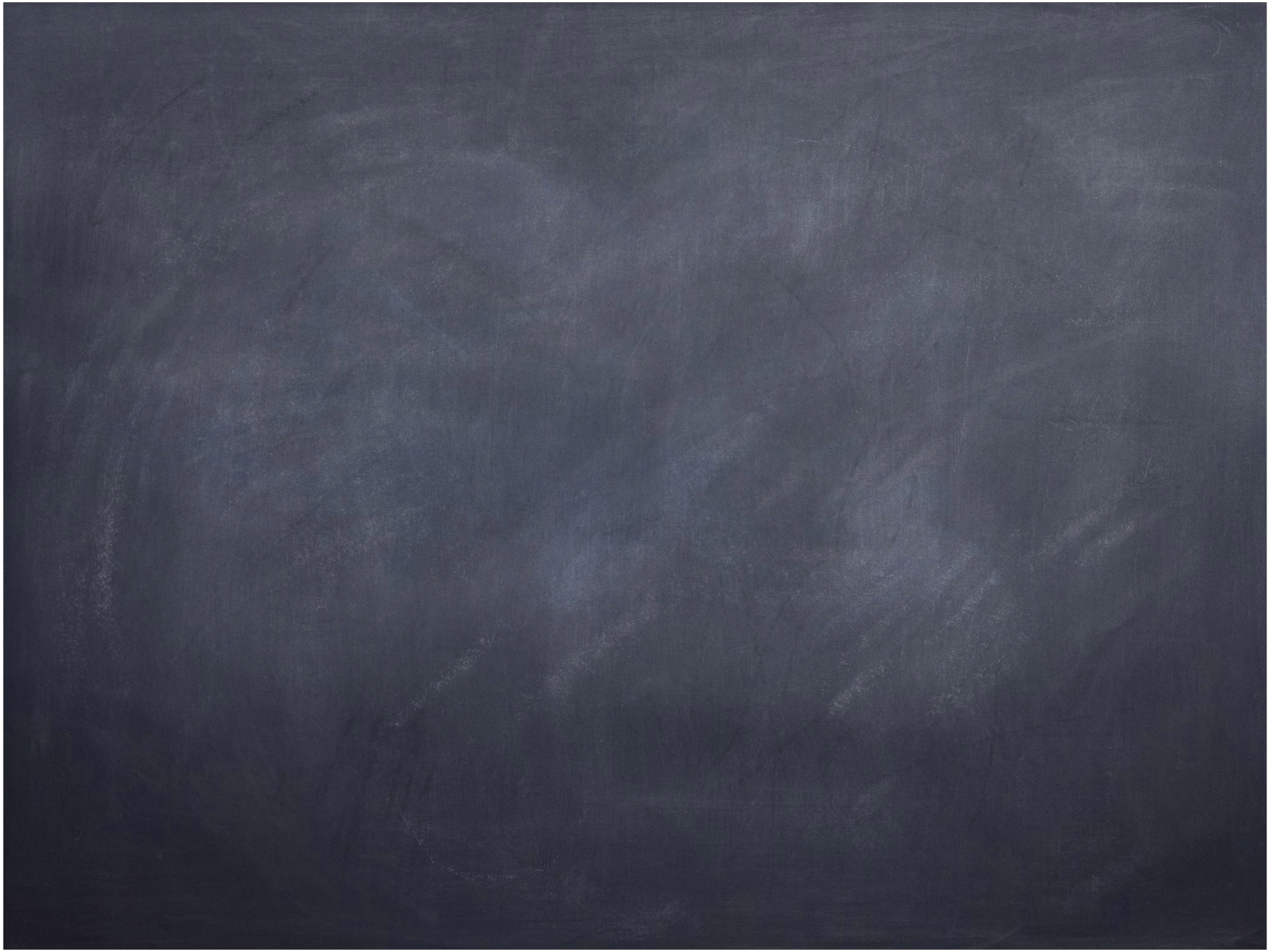
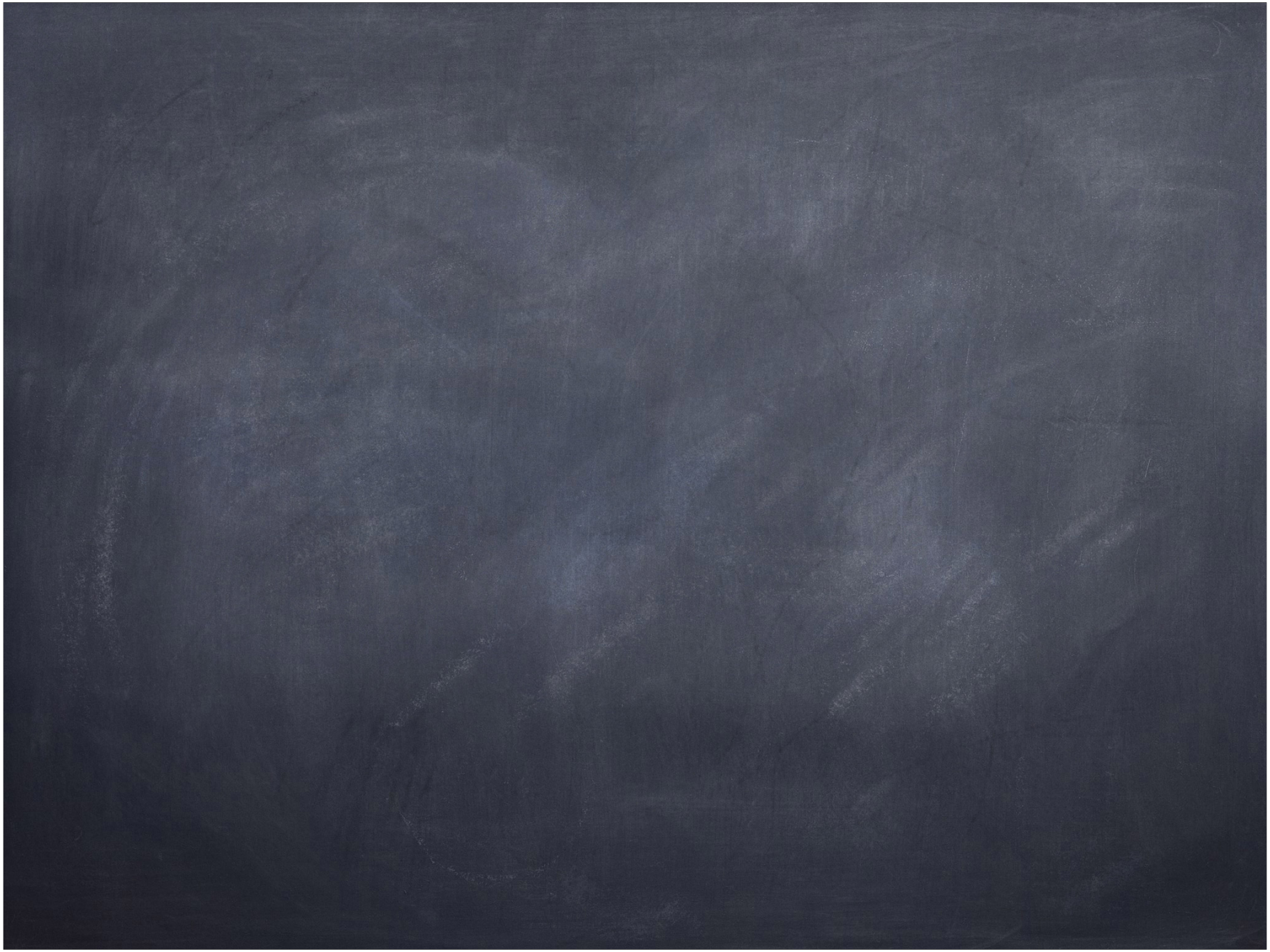
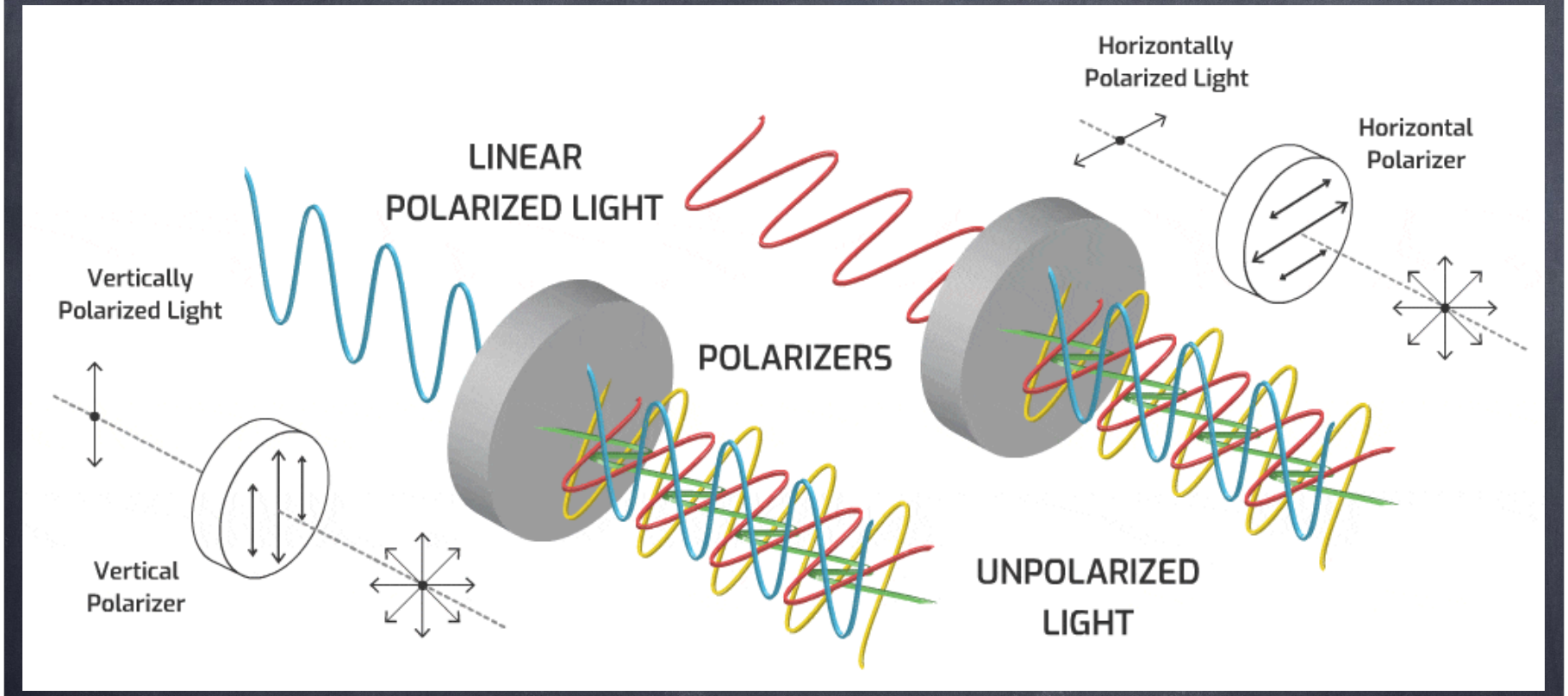
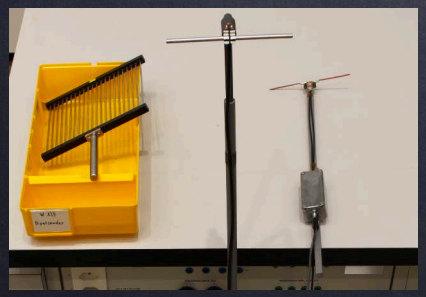
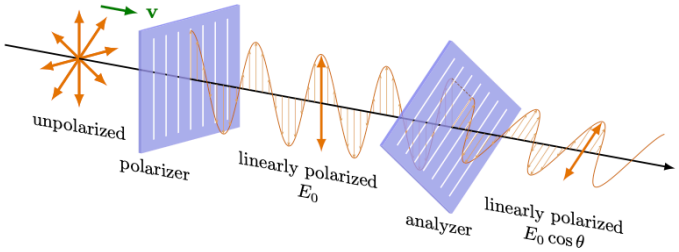


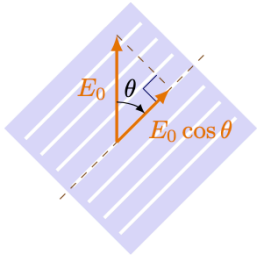



Horizontally
Polarized Light
Horizontal
Polarizer
LINEAR
POLARIZED LIGHT
Vertically
Polarized Light
POLARIZERS
Vertical
Polarizer
UNPOLARIZED
LIGHT

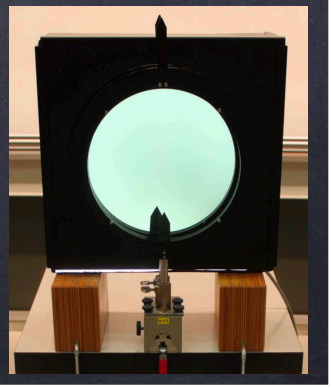


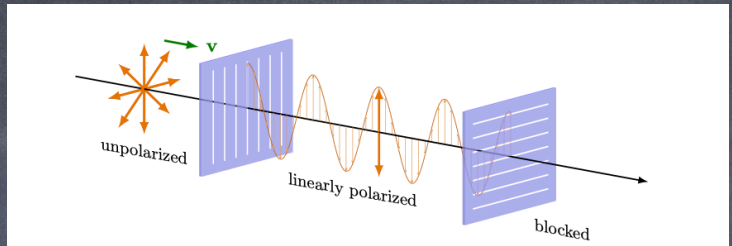


(a) Initially unpolarized light beam gets linearly polarized. The transmitted electric field is reduced to $E_0 \cos\theta$.

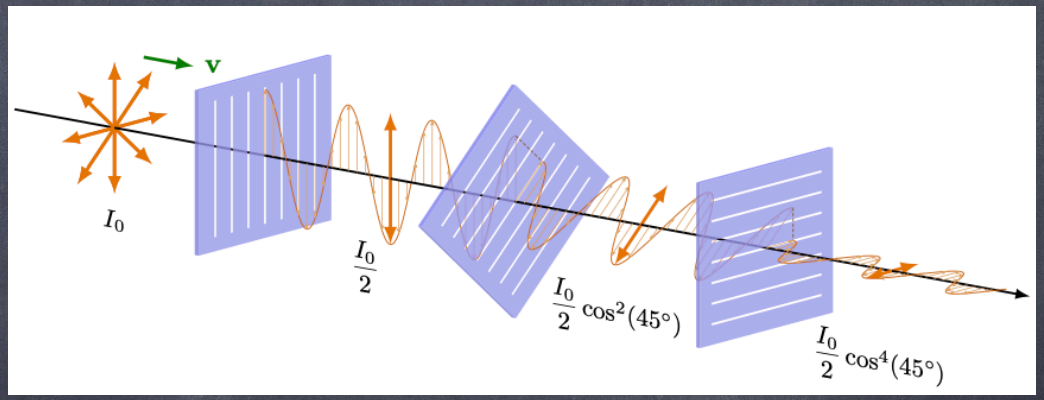


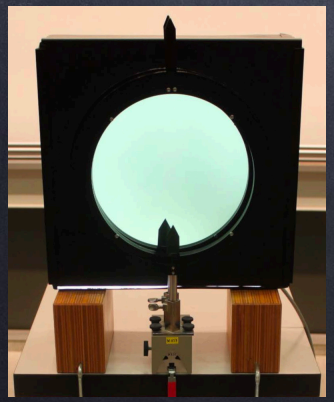
(b) Polarizer only lets through the component parallel to its polarizing axis.

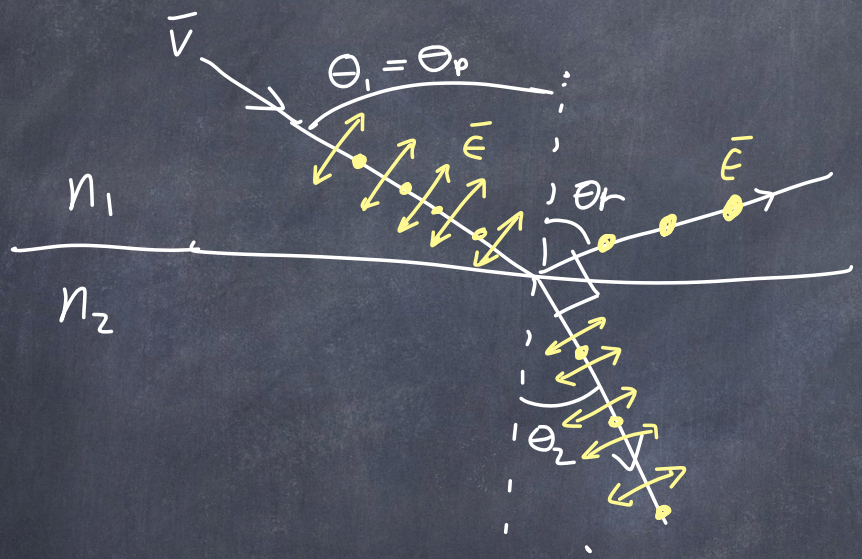


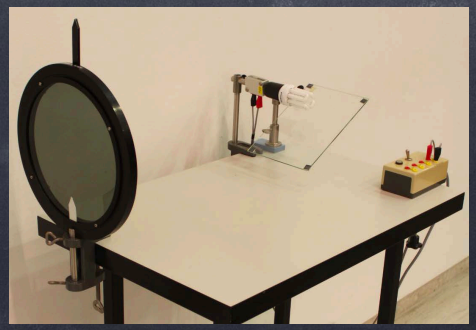


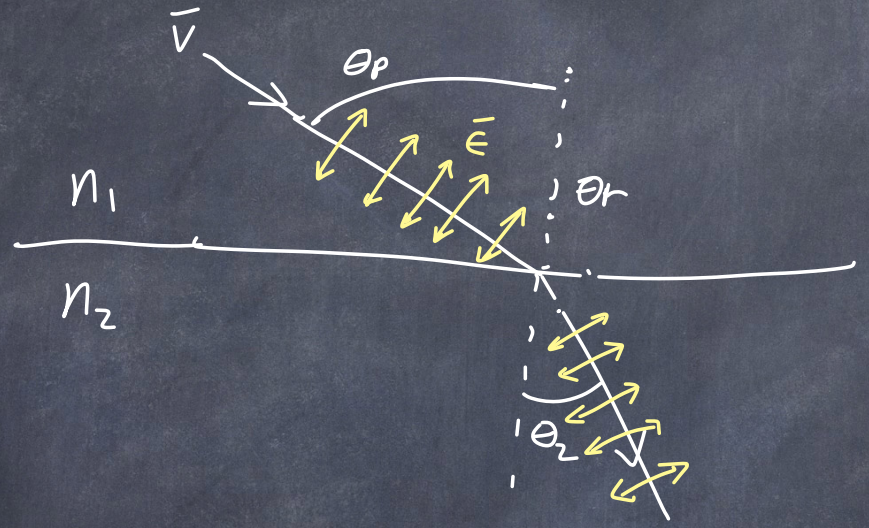
(c) If the axes of two subsequent polarizer differ by 90°, all light gets blocked.

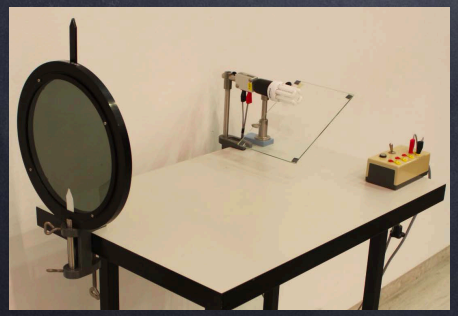





$\bar{V}$
$\theta_1 = \theta_p$
$\bar{E}$
$\bar{E}$
n_1
θ_r
n_2
θ_2




$\bar{v}$
θ_p
$\bar{\epsilon}$
n_1
θ_r
n_2
θ_2



To calculate the B-field and E-field using Ampere's law and Gauss' law, one must define a closed surface.

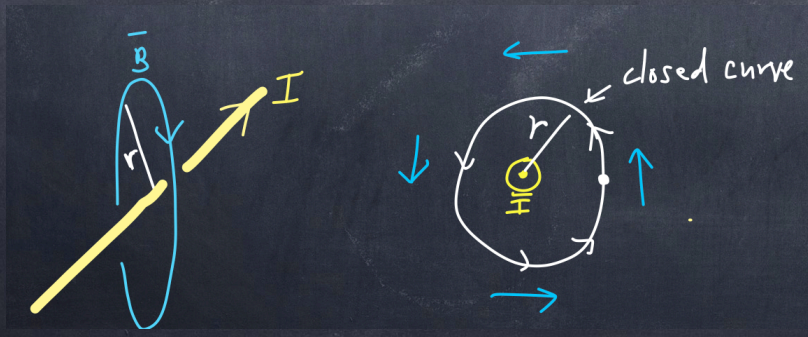
1 | 36 | 6

FALSE

Ampere's Law

$$\oint_{\text{closed curve}} \bar{B} \cdot d\bar{\ell} = \mu_0 I_c$$

I_c : current passing through the closed curve.



The sum of the voltages into a junction are the same as the sum leaving the junction.

1 | 24 | 18

FALSE

(iv) The sum of currents into a junction must equal the sum of currents out of the junction.

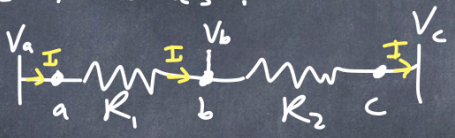
Current decreases when it moves through a resistor.

17

26

FALSE

Resistors in series:



Note: opposite rules as for capacitors

Equivalent resistance: $R_{eq} = R_1 + R_2 + \dots$

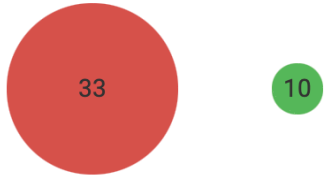
$V_b = V_a - IR_1$

$V_c = V_a - IR_1 - IR_2$

$I_a = I_b = I_c = I$

Potential decreases, current stays same.

A complete loop around any circuit will be equal to the battery voltage.



FALSE

(i) Any complete loop around a circuit has a total potential change of zero.
(Potential difference between 2 points is always the same, no matter which path)

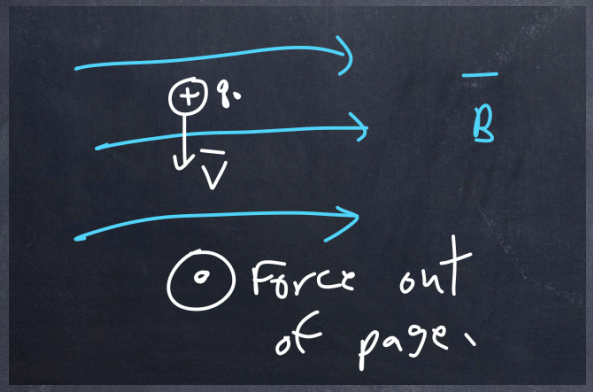
Loop: $+\mathcal{E} - IR = 0$

$IR = \mathcal{E}$

$I = \frac{\mathcal{E}}{R} = \frac{10V}{100\Omega} = 0.1\ A$

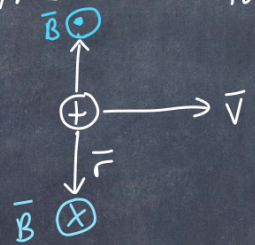
Since a moving charged particle produces a magnetic field, the charged particle will feel a force from its own movement.

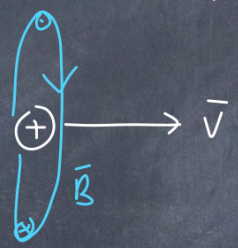
3 | 26 | 14



Now: A moving charge $\oplus \rightarrow \vec{v}$ generates its own magnetic field.

The direction of $\vec{B}$ is $\vec{v} \times \vec{r}$





The magnetic field loops around the direction of motion.

The magnetic flux through 10 loops of optical fiber is 10 times more than through 1 loop.

3 | 17 | 23

Magnetic flux:

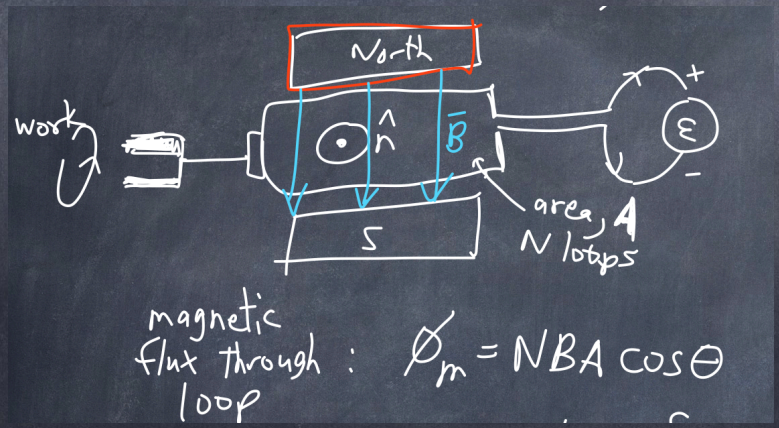
For a loop $\perp$ to $\vec{B}$-field

we can quantify the $\vec{B}$-field by

$$\Phi_m = BA$$

A: area

where Φ_m is known as the magnetic flux



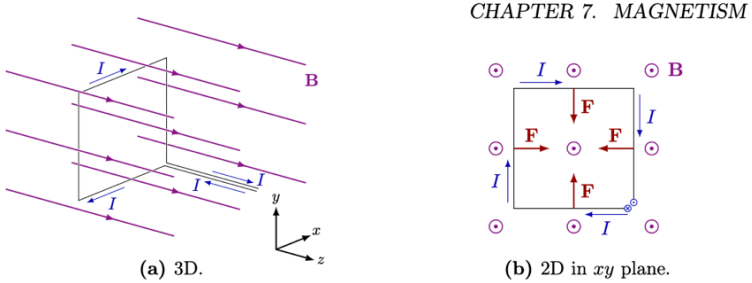
magnetic flux through loop: $\Phi_m = NBA\cos\theta$

A 4-sided loop of current, in which all 4 sides are perpendicular to a magnetic field, feels zero net force, but a non-zero net torque.

2

28

13

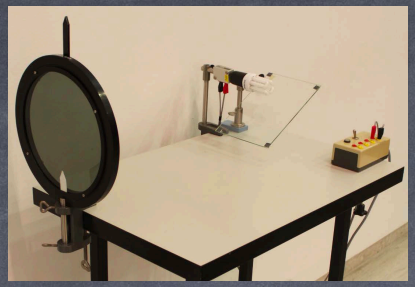


(a) 3D. (b) 2D in xy plane.

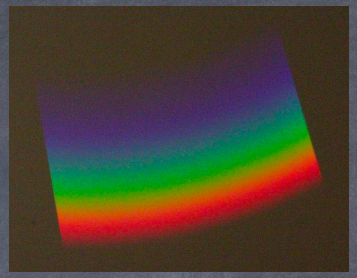
Figure 7.9: Rectangular current loop in an external, uniform magnetic field $\mathbf{B} = B\hat{\mathbf{z}}$.

No net force, no net torque

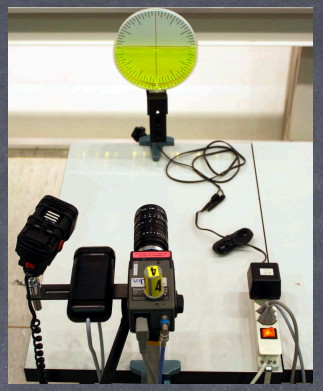
W51



W138

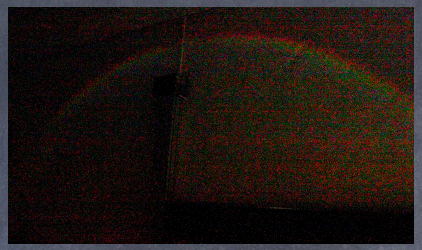


W100

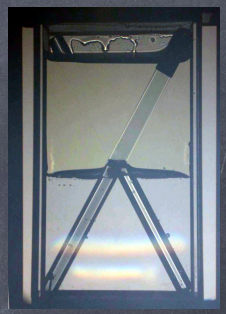


W73

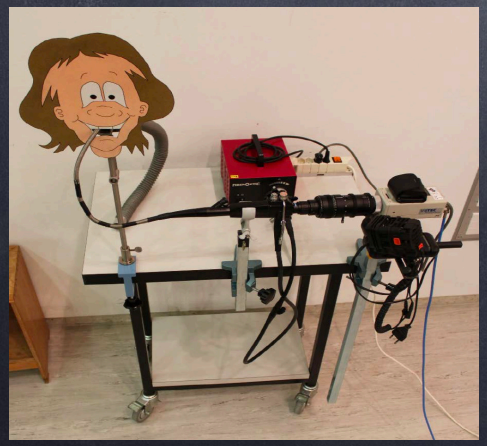
W77



W95



W93



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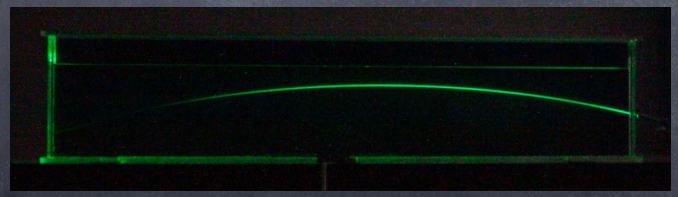

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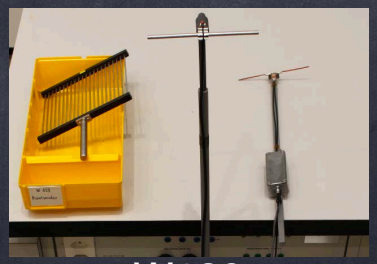

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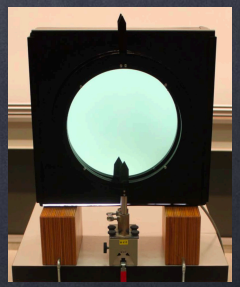

W137