Computer Graphics

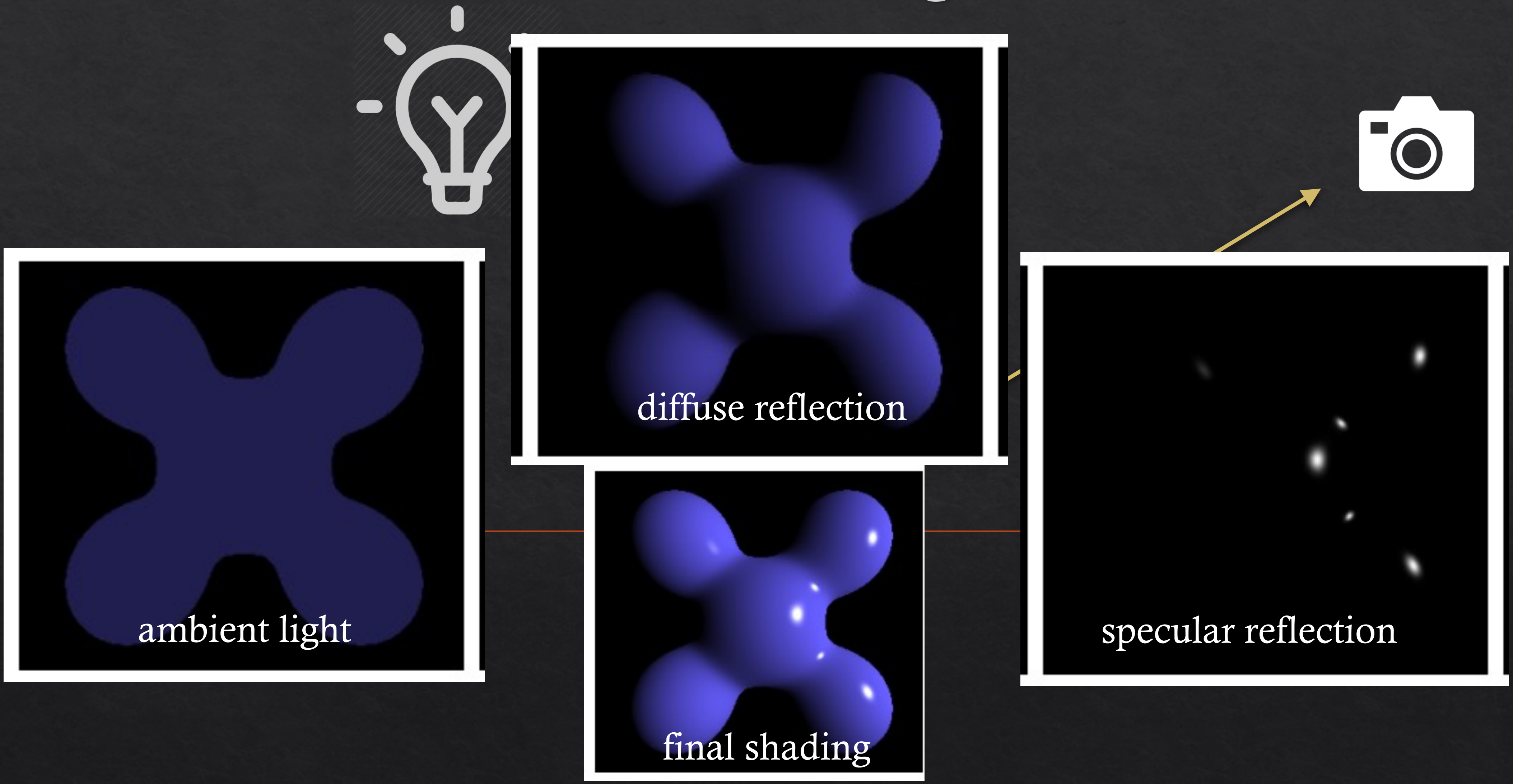
Lecture 7: Raytracing - advanced

Kartic Subr

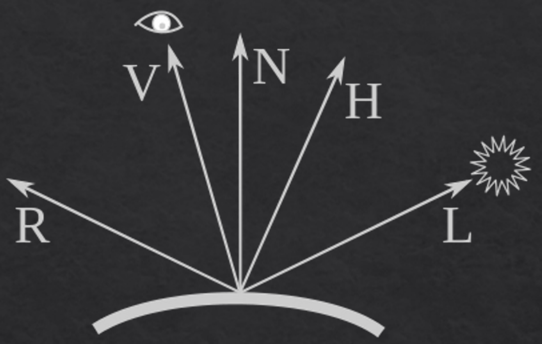
Recap

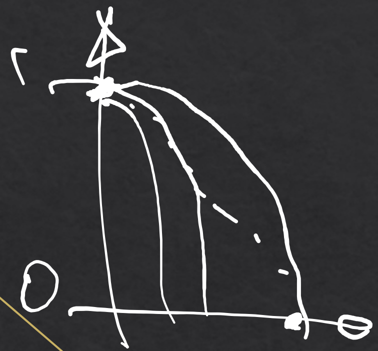
for each pixel p
    trace ray
    shade hit point

Shading


diffuse reflection
ambient light
specular reflection
final shading

Phong shading



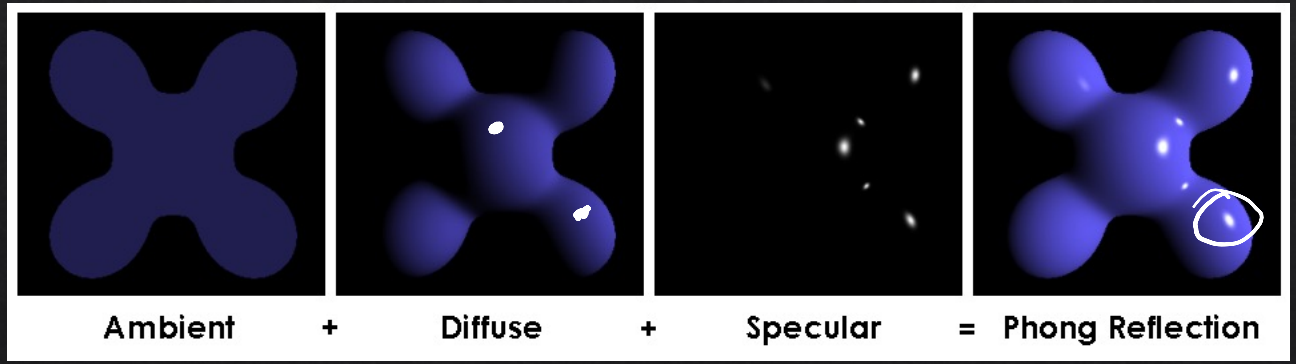


material property

$$I_\mathrm{p} = k_\mathrm{a} i_\mathrm{a} + \sum_{m \in \text{lights}} \left(k_\mathrm{d} (\hat{L}_m \cdot \hat{N}) i_{m,\mathrm{d}} + k_\mathrm{s} (\hat{R}_m \cdot \hat{V})^{\alpha} i_{m,\mathrm{s}} \right)$$

ambient — diffuse — specular

light property

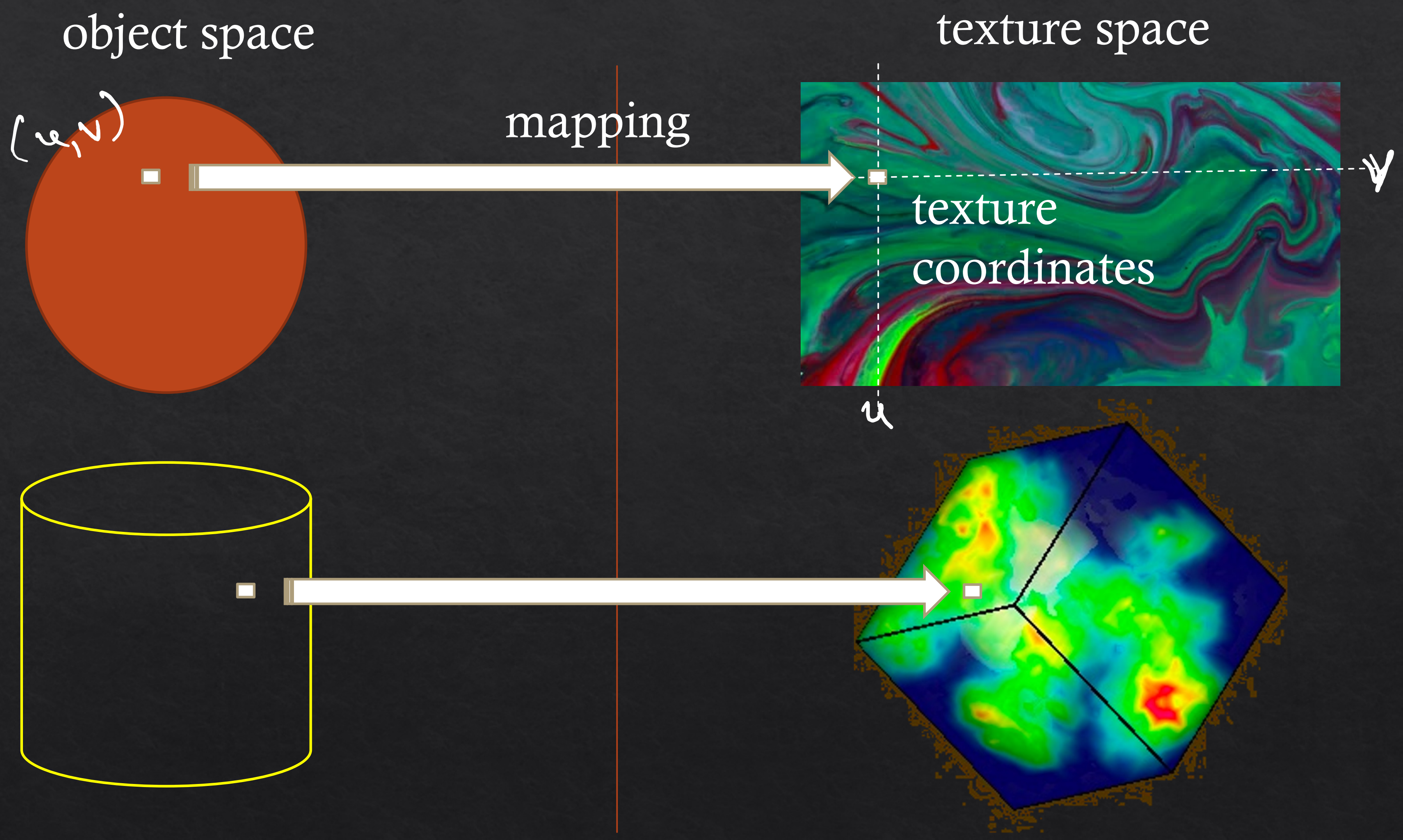


source:wikipedia

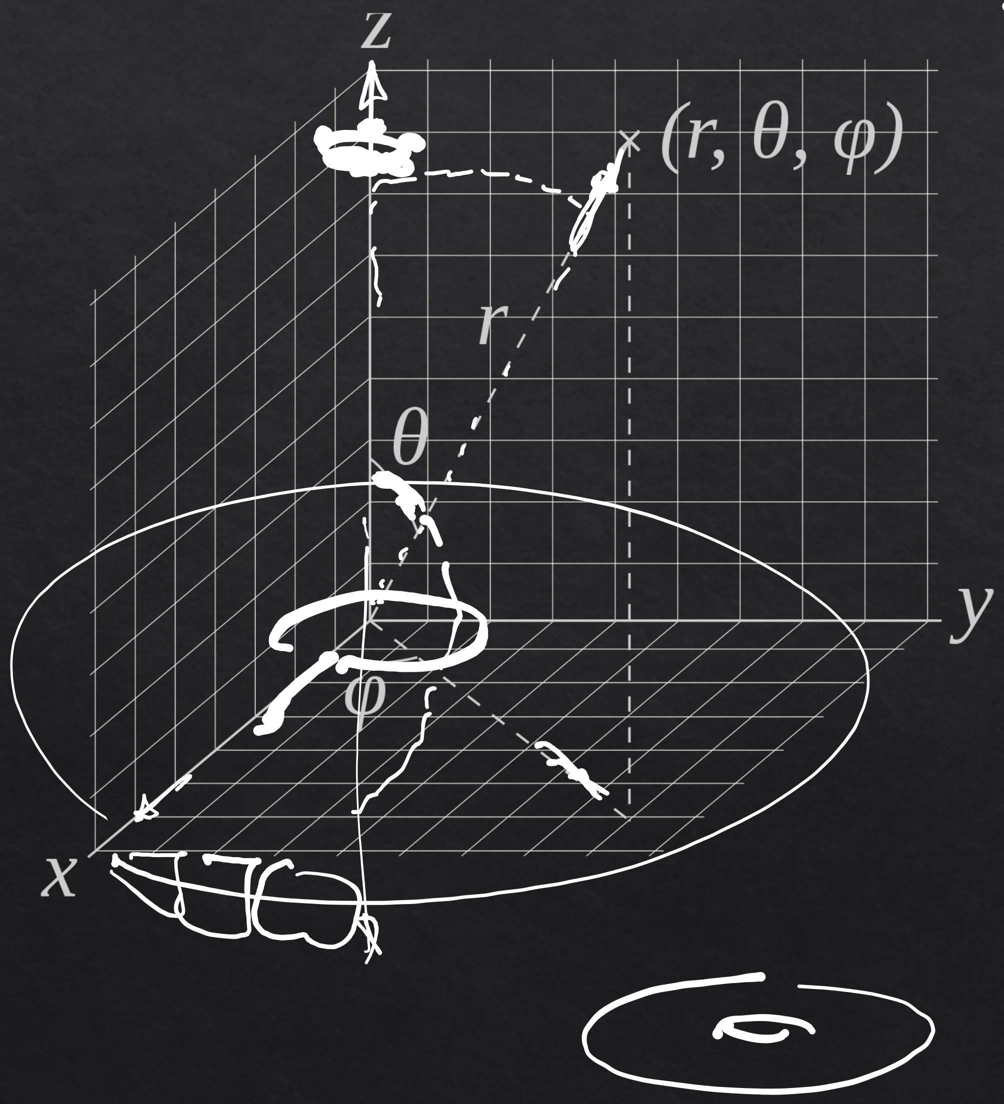
R is the mirror reflection direction

How to deal with texture?

How to deal with texture?



Texture coordinates on a sphere



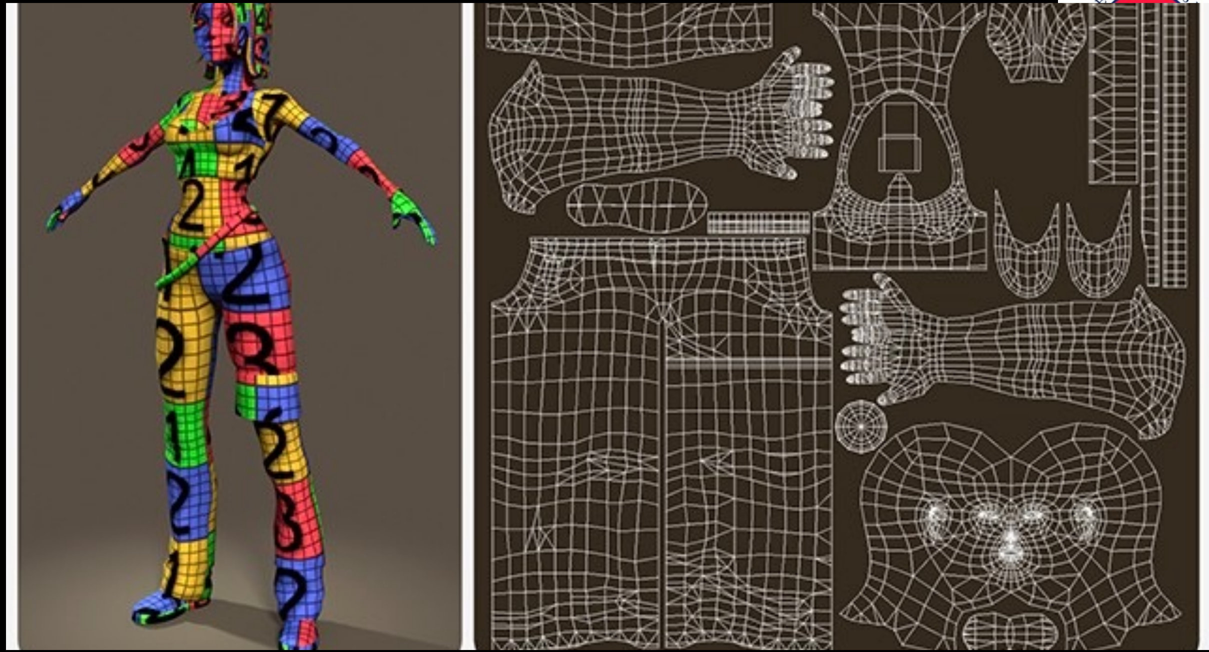
$$y = r \sin\theta \sin\phi$$
$$x = r \sin\theta \cos\phi$$
$$z = r \cos\theta$$

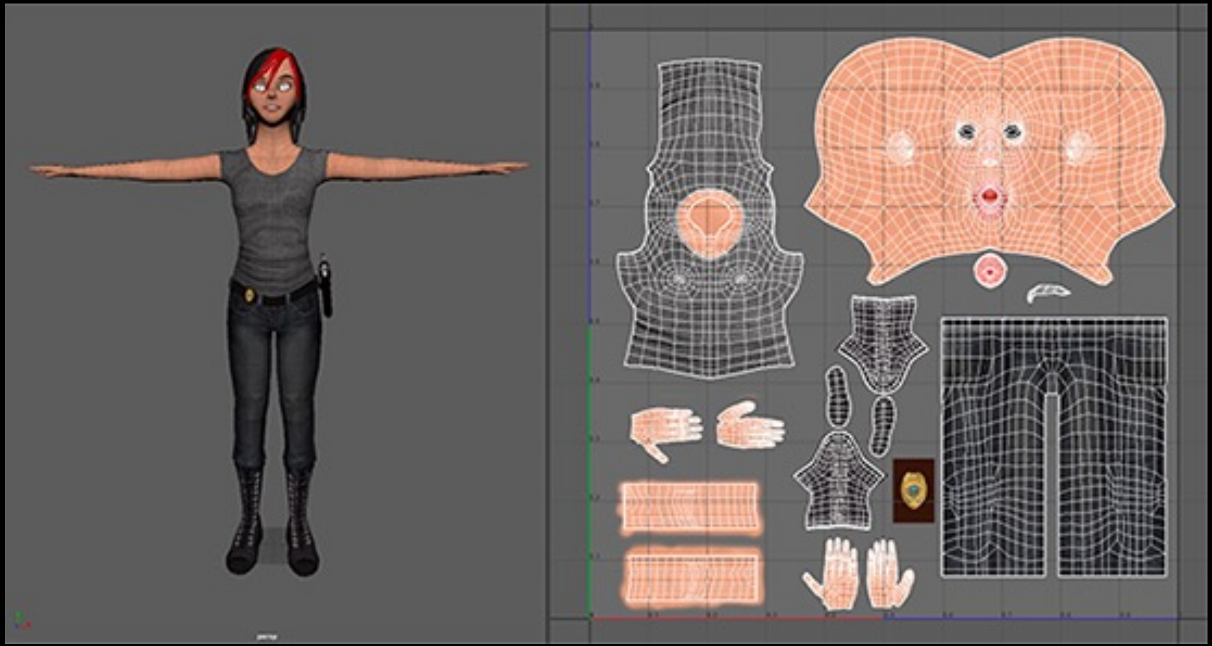
$$\theta \in [0, \pi] \quad \phi \in [0, 2\pi]$$

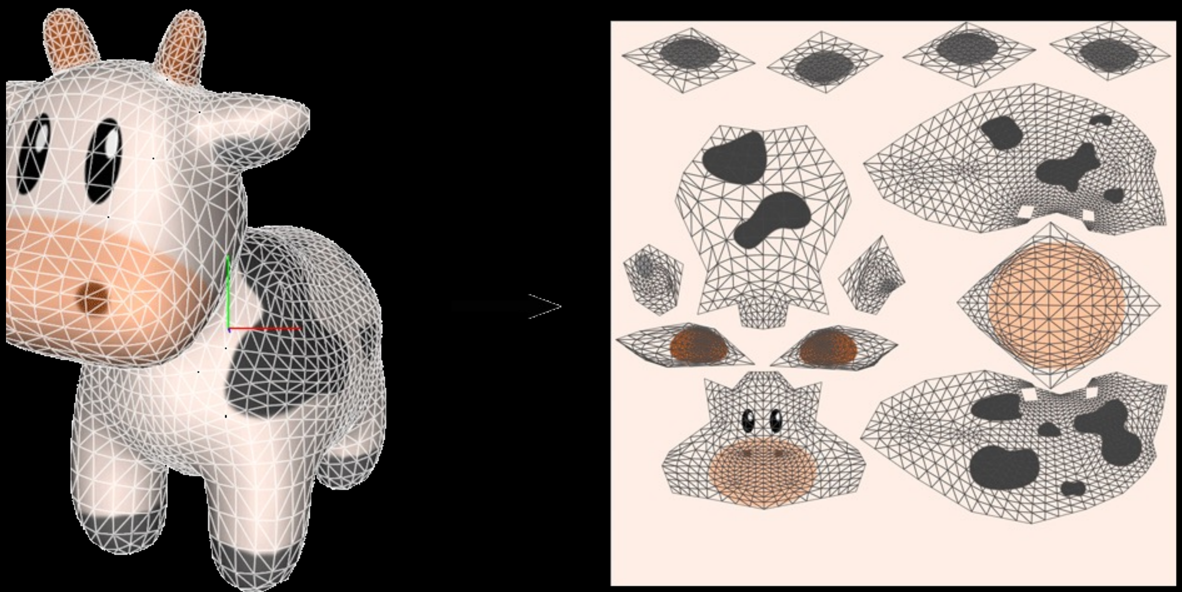
$$(u, v)$$
$$u \in [0,1]$$
$$v \in [0,1]$$

$$u = (\theta + \pi)/2\pi$$
$$v = \phi/2\pi$$
$$u = \theta/\pi$$

$$\theta = \operatorname{acos} z/r$$
$$\frac{y}{x} = \frac{r \sin\theta \sin\phi}{r \sin\theta \cos\phi}$$
$$\tan\phi = y/x$$
$$\phi = \operatorname{atan} y/x$$

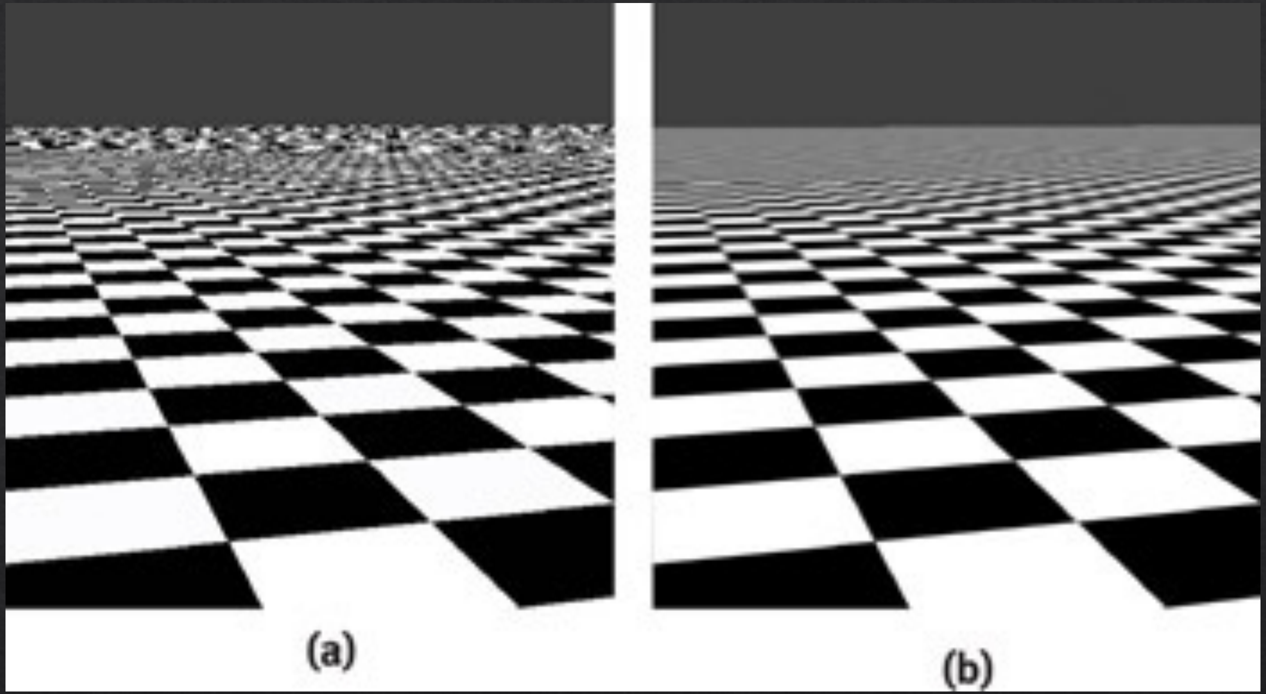






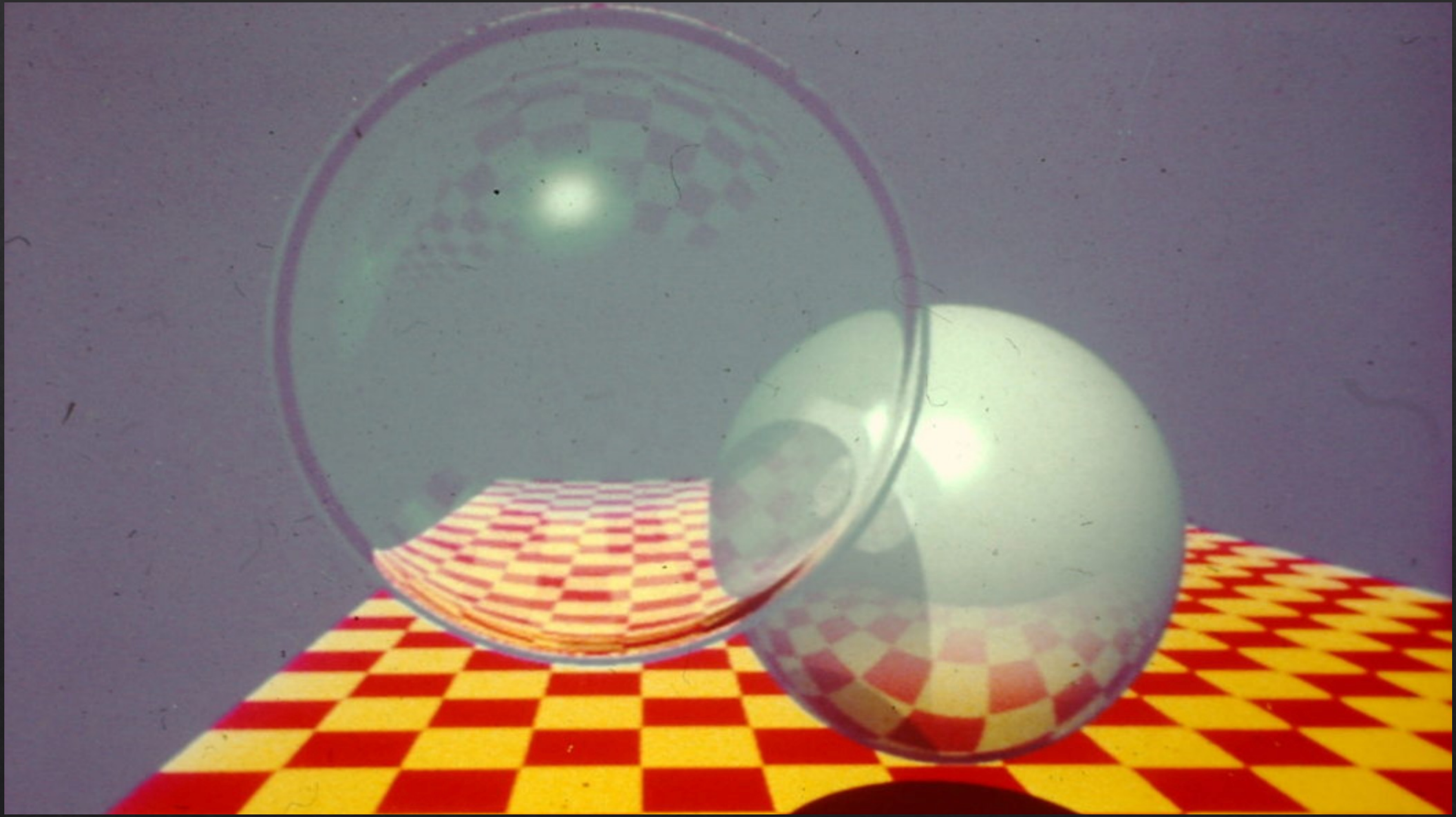
Problems

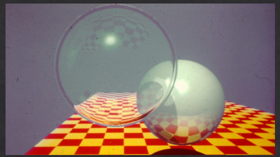
- How to generate maps?
- Finite resolution
- Artifacts
- More later!



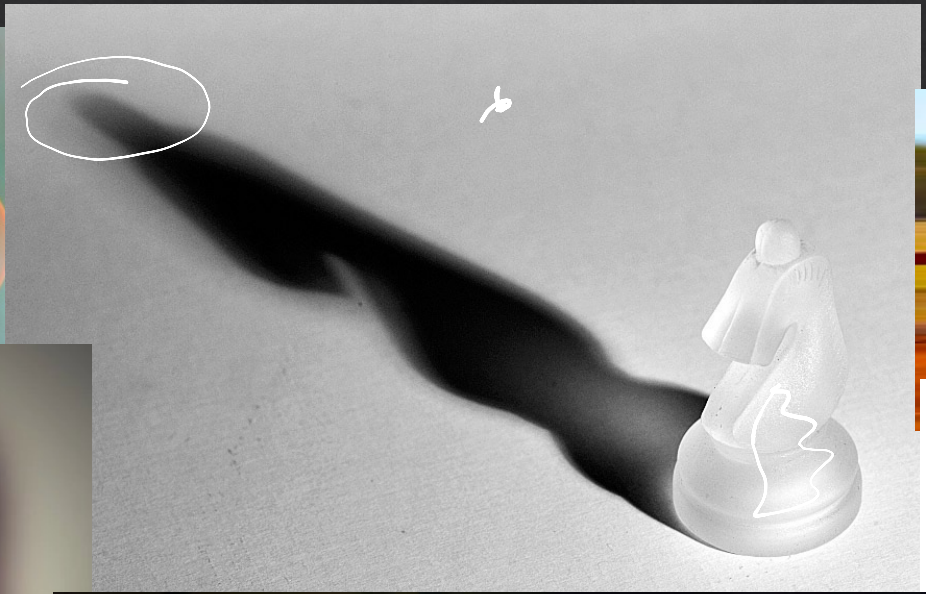
http://www.cemyuksel.com/courses/conferences/siggraph2017-rethinking_texture_mapping/rethinking_texture_mapping_course_notes.pdf

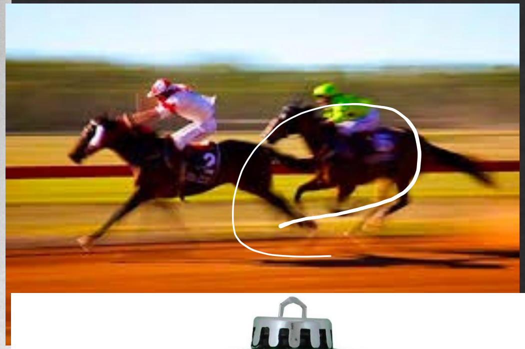
What's wrong with this image?

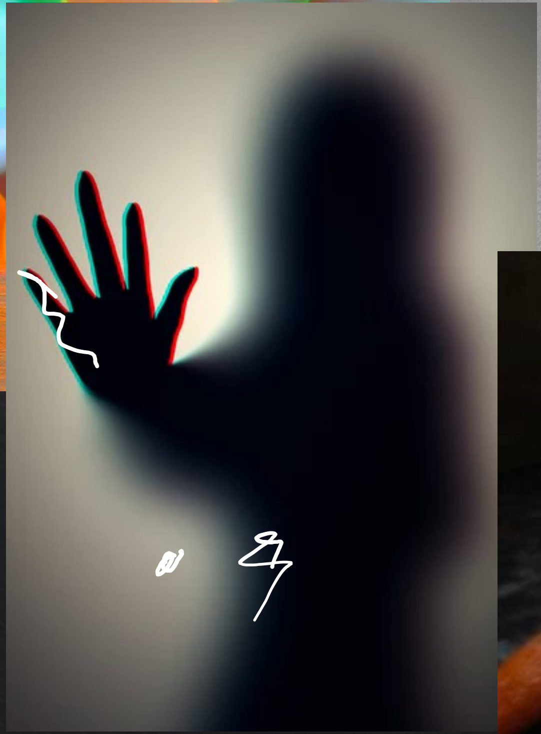




Does not have any blur!







What causes blur?

motion blur (shutter speed)

DoF (aperture)

shadow (dist from occl / size of light)

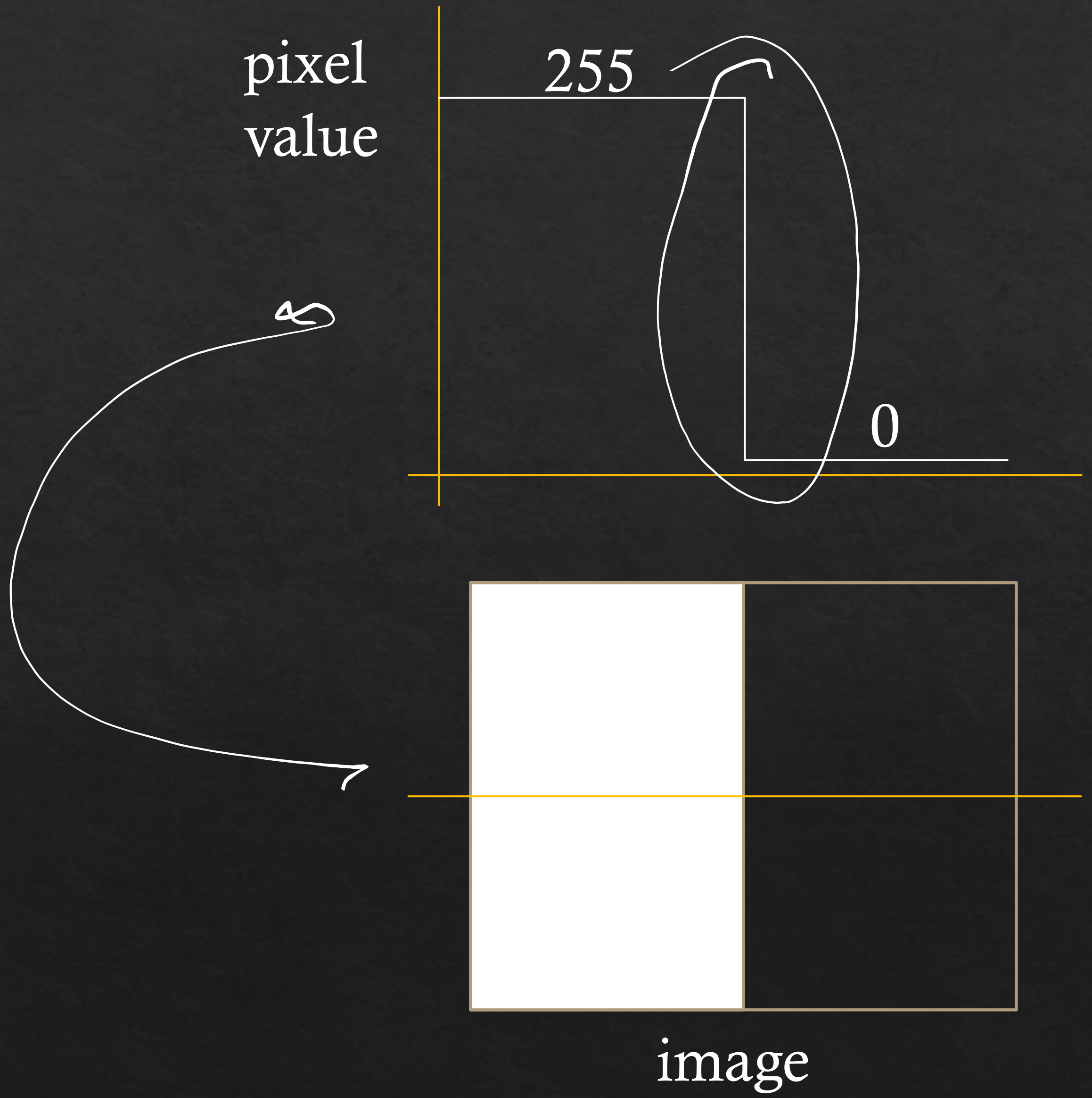
light scattering

material refl'
transmittance
volumetric

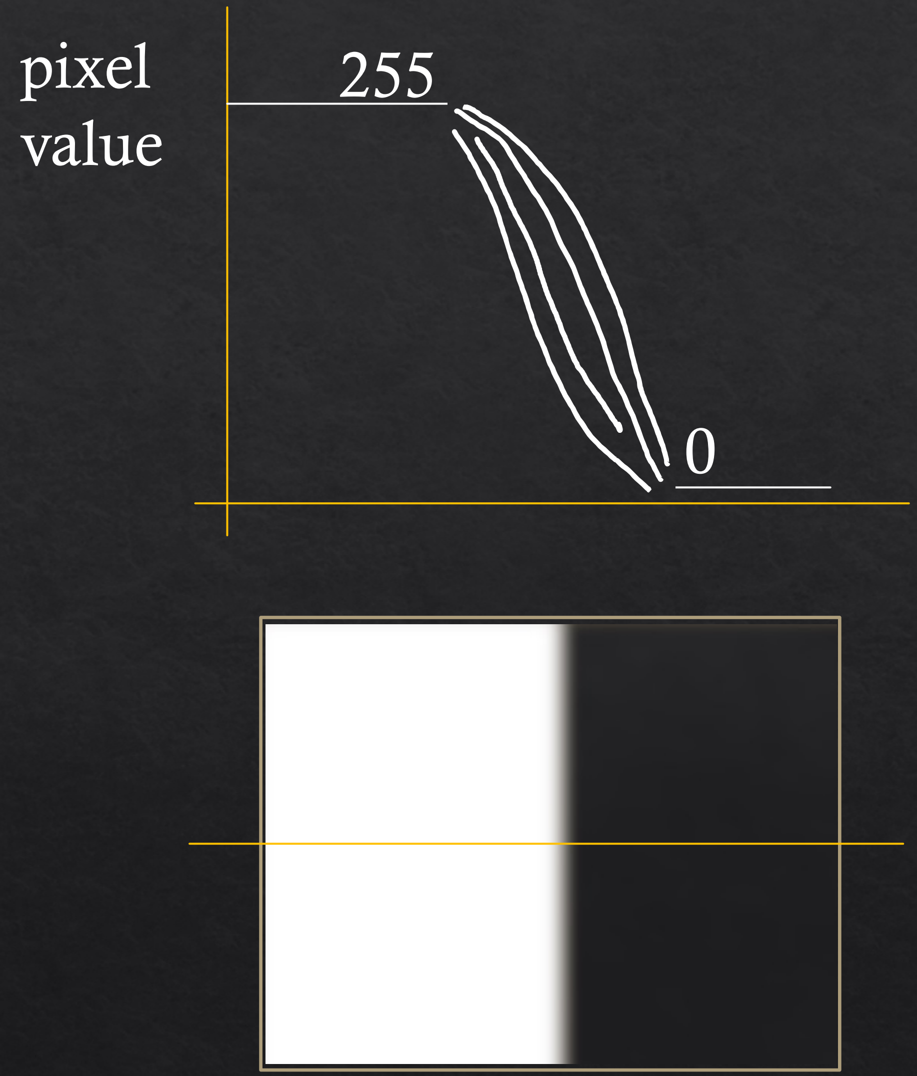
averaging

Sampling

A step function (edge)

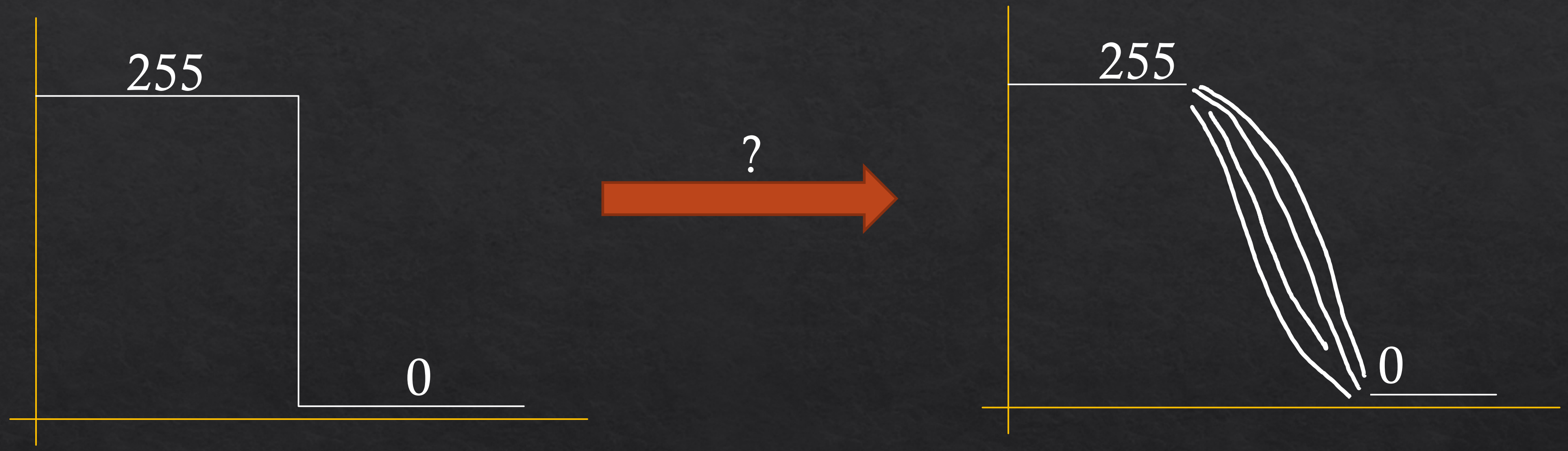


A blurred step function

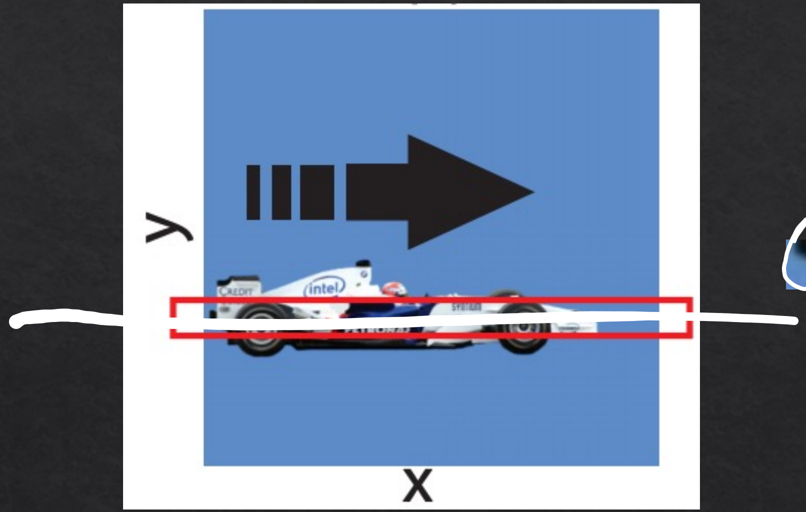


image

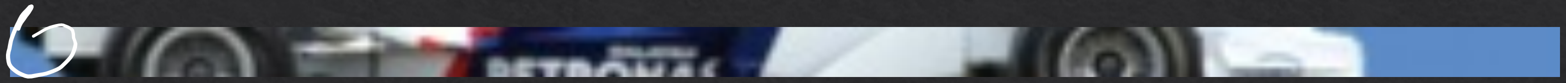
Fundamental operation?



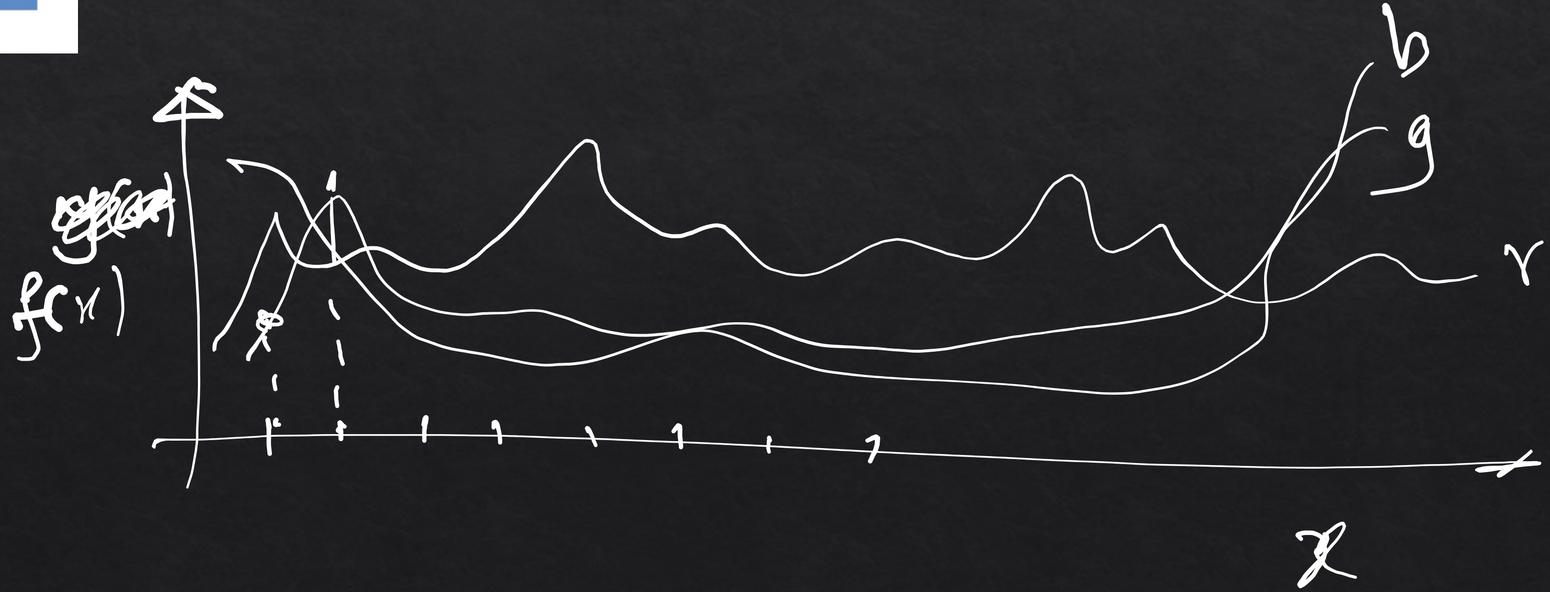
Example: photo of a car



slice in y



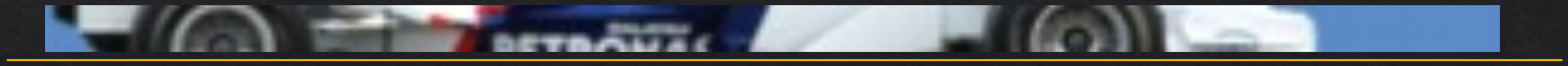
f(x)



Example: motion blur

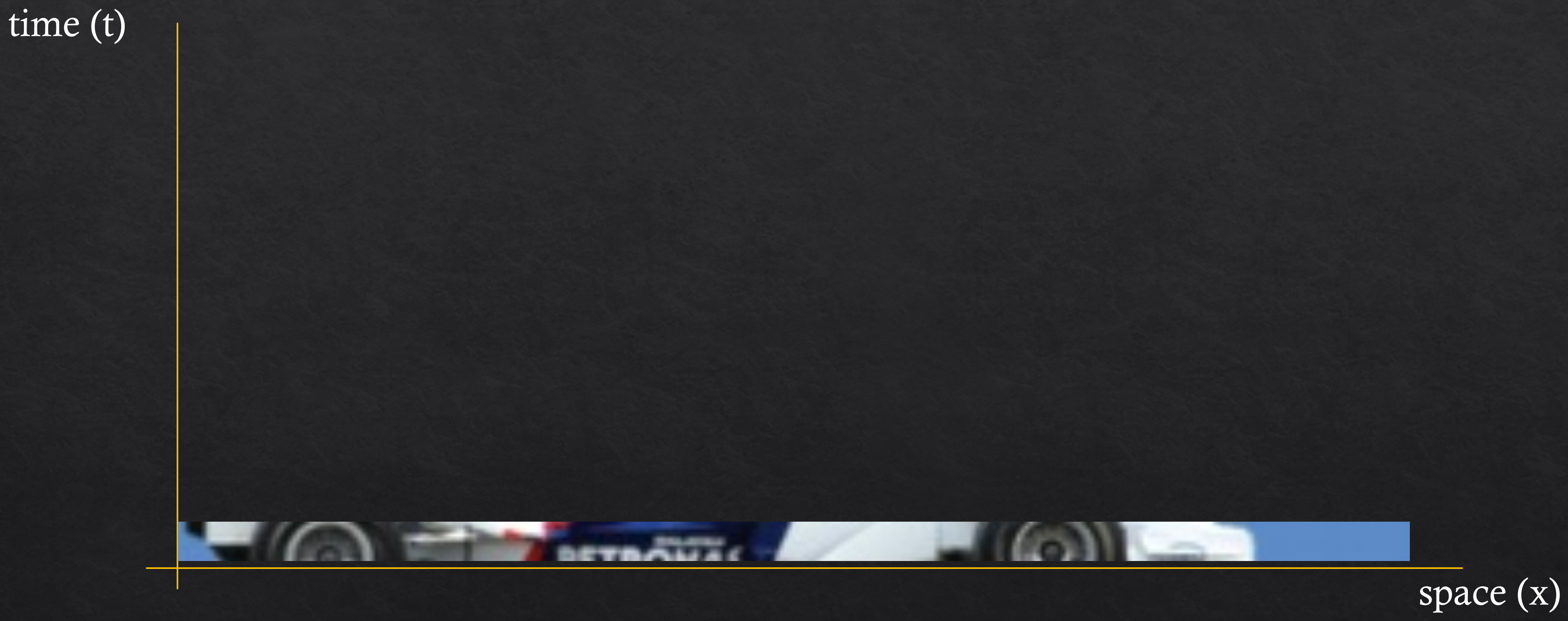
Example: slice is a 1D function

f(x)



space (x)

Example: add time as second dimension



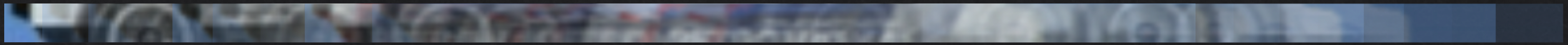
Example: stationary car

Example: car moving to the right

$$f_t(x) \approx f(x-t)$$

Example: sum of shifted positions

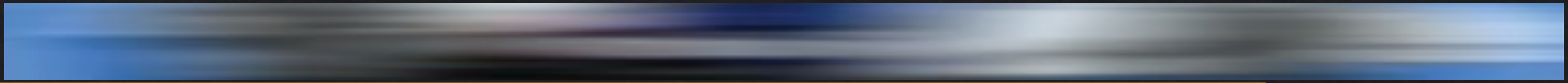
$$\sum_{i=0}^{N} f(x - t_i)$$



space (x)

Example: motion blur

$$\int_0^T f(x-t)\,dt$$



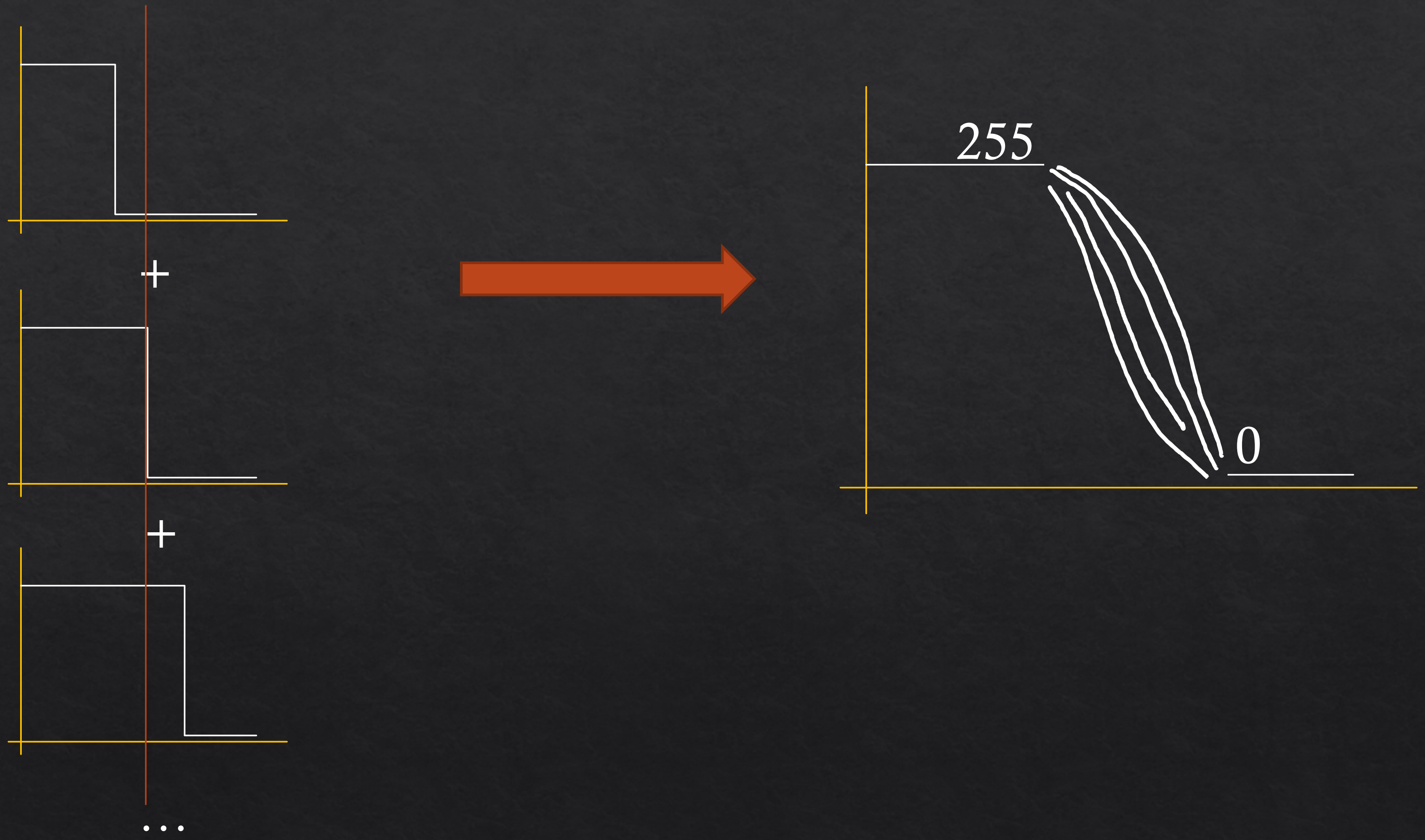
space (x)

Sums of shifted functions!

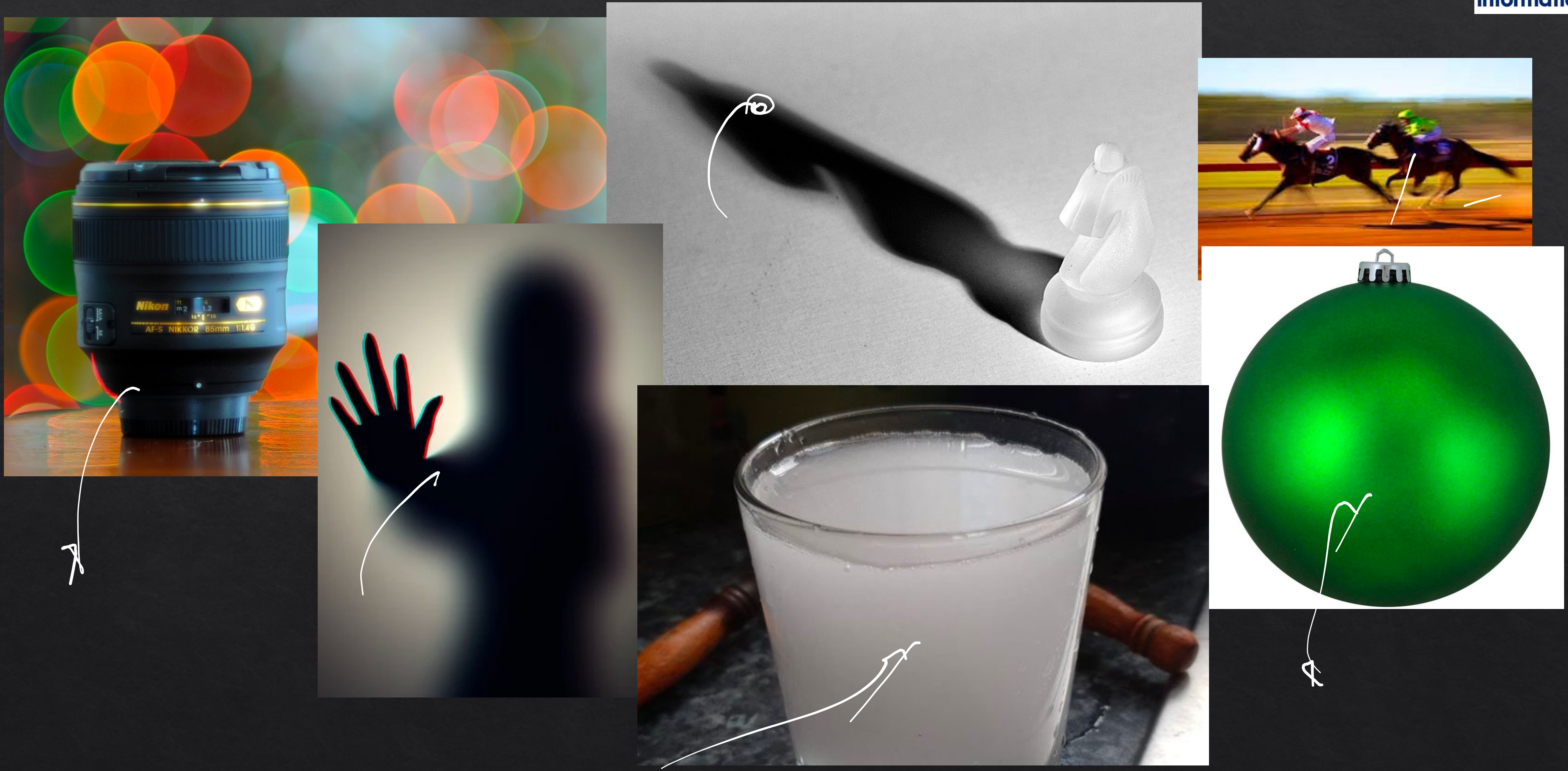
$f(x)$

$f(x-t_1)$

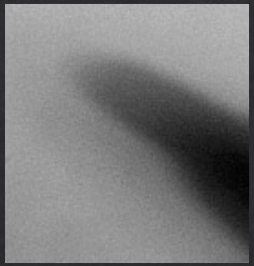
$f(x-t_2)$



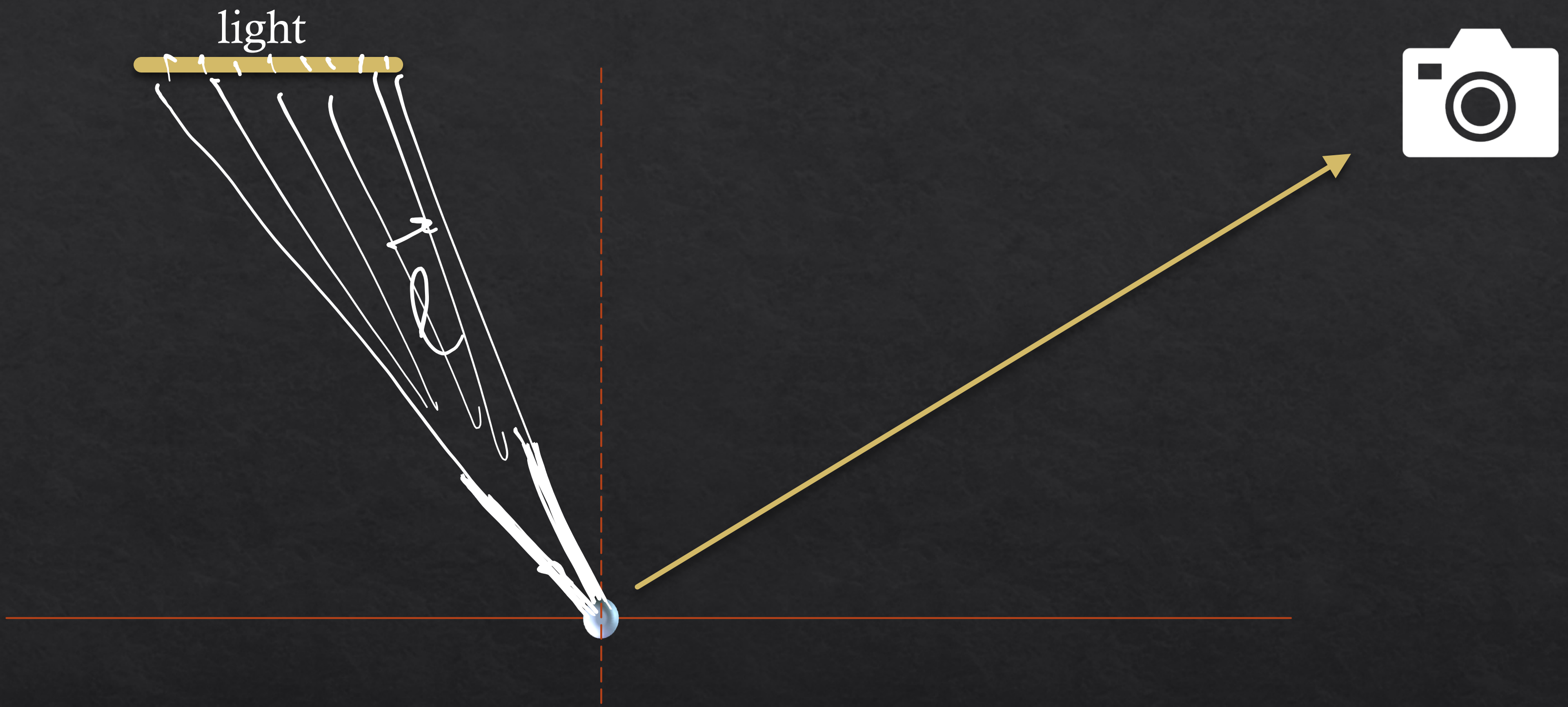
Can you spot the "shifted sums" in each case?



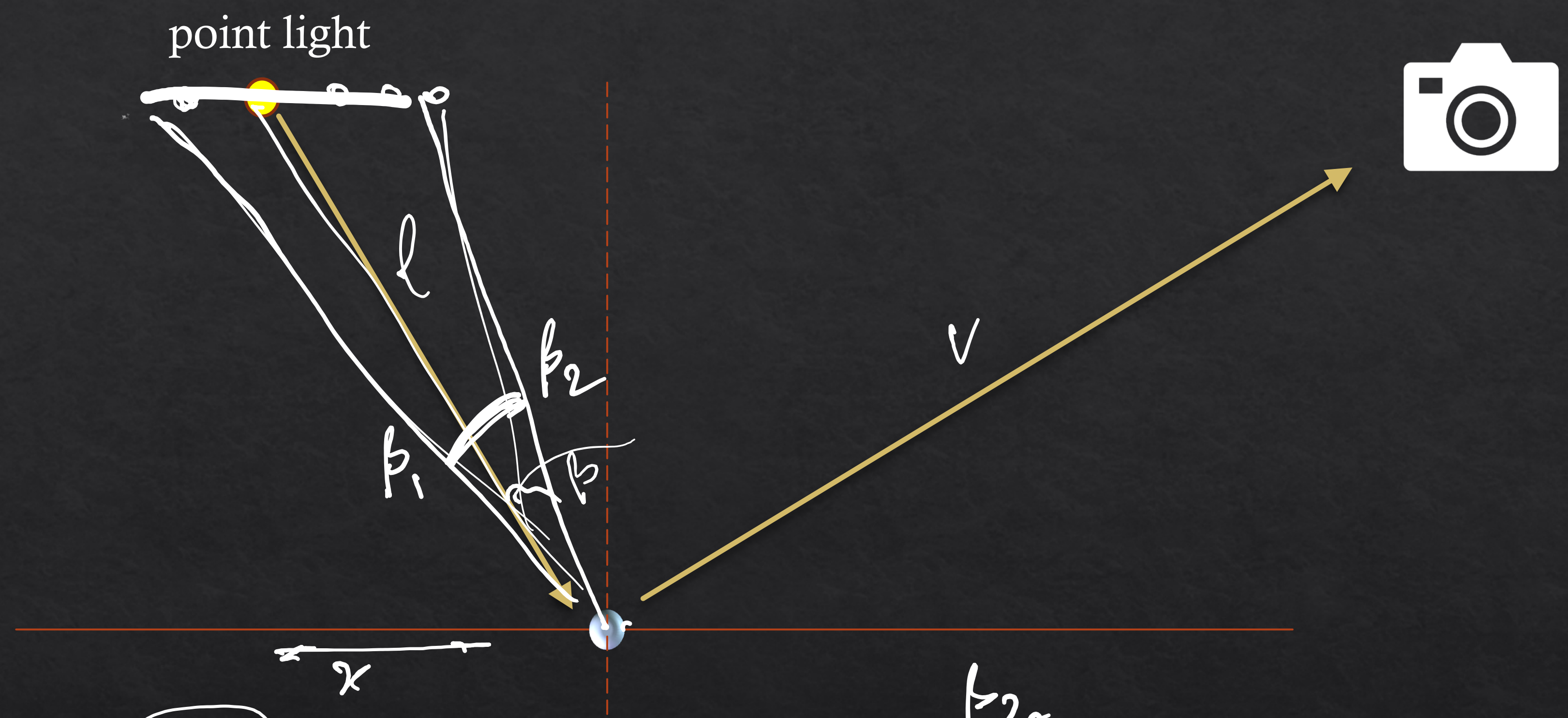
Soft shadow due to area light



Example: Area light



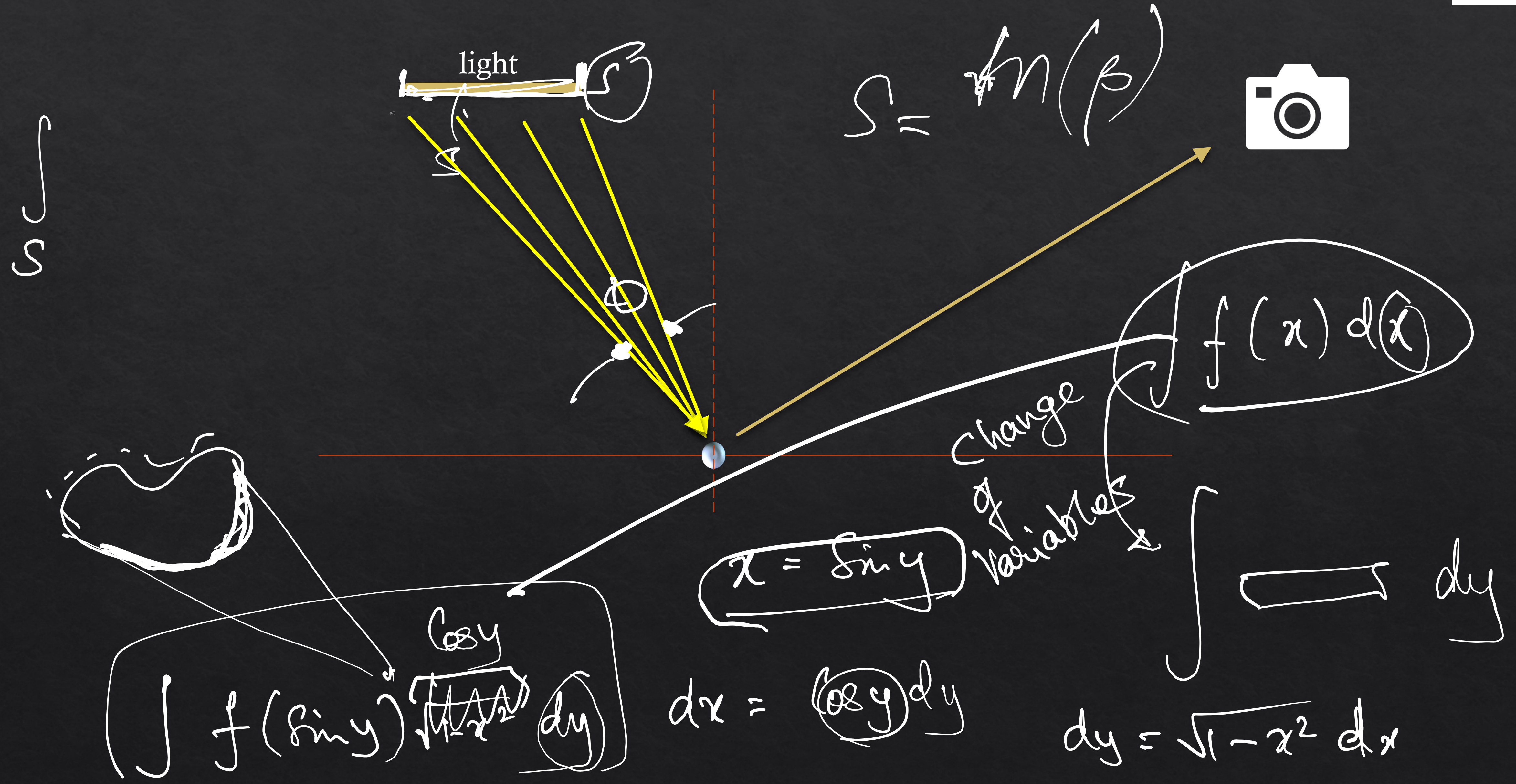
Example: Area light



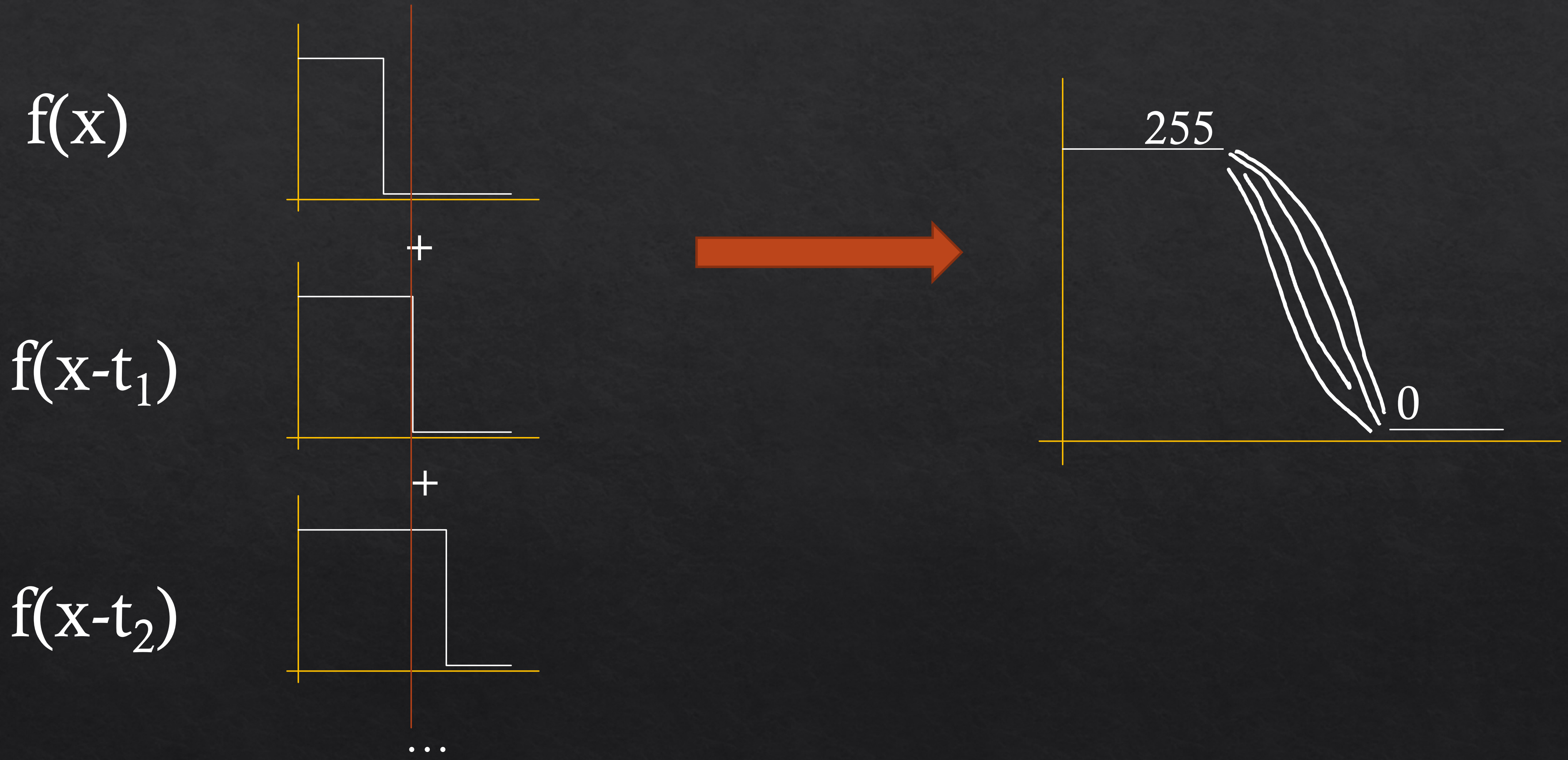
$$f_{ps}(x, l, r, m, n, v)$$

$$\int_{\beta_1}^{\beta_2} f_{ps}(x, l(\beta), r(\beta), m, n, v)\, d\beta$$

Area light: integrate over angle



Sums of shifted functions!

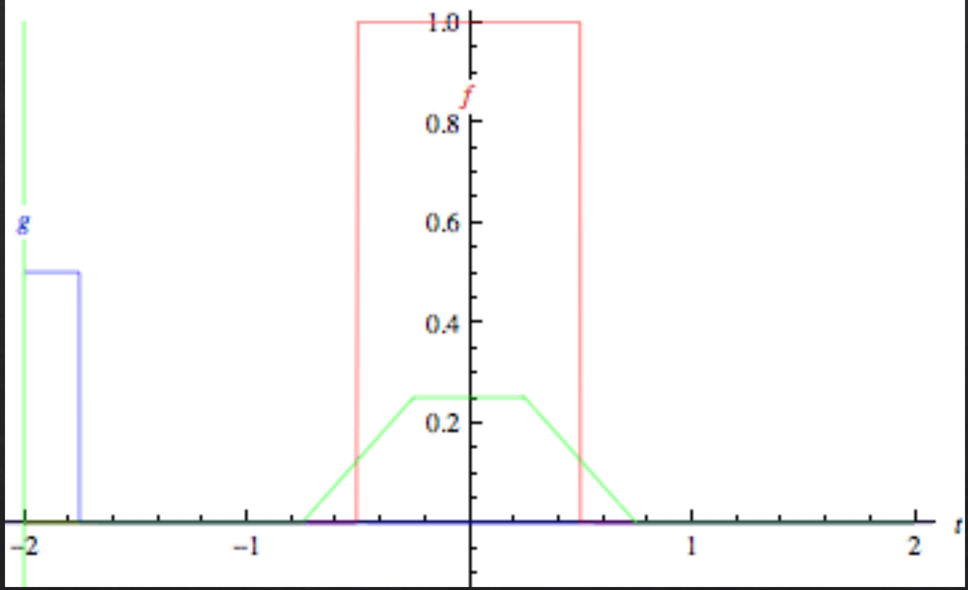


Sums of weighted, shifted functions!

$$h(x) = \int f(x-t)\,dt$$

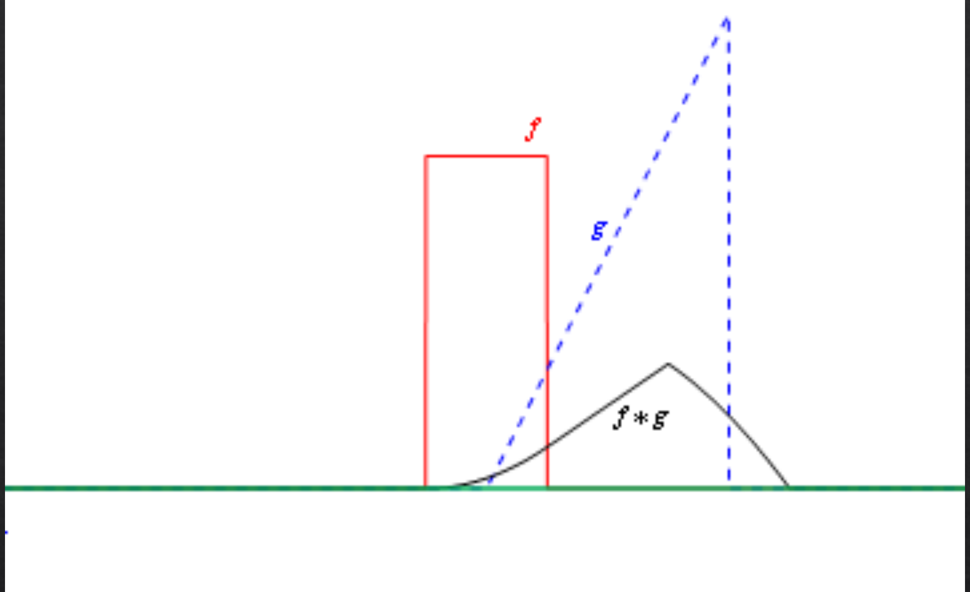
$$h(x) = \int f(x-t)\,g(t)\,dt.$$

Sums of weighted, shifted functions!

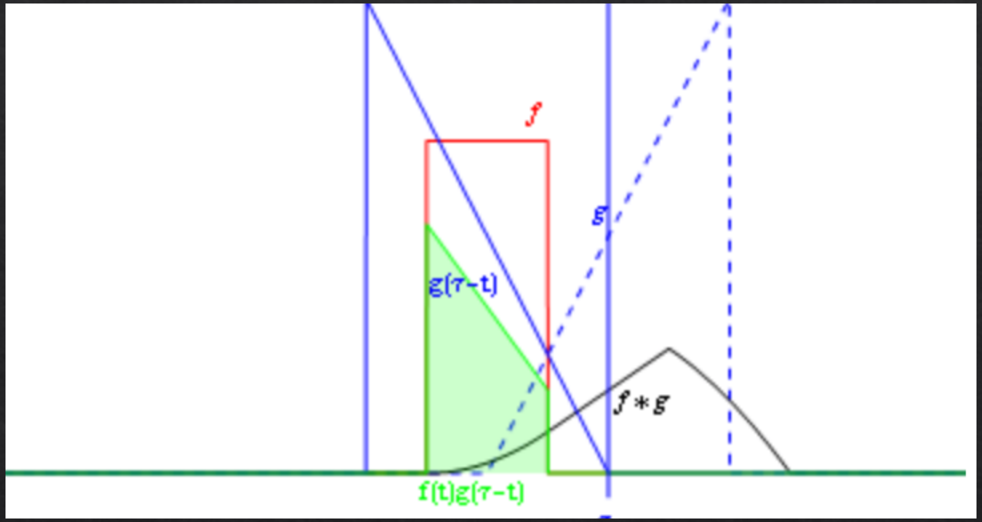


wikipedia

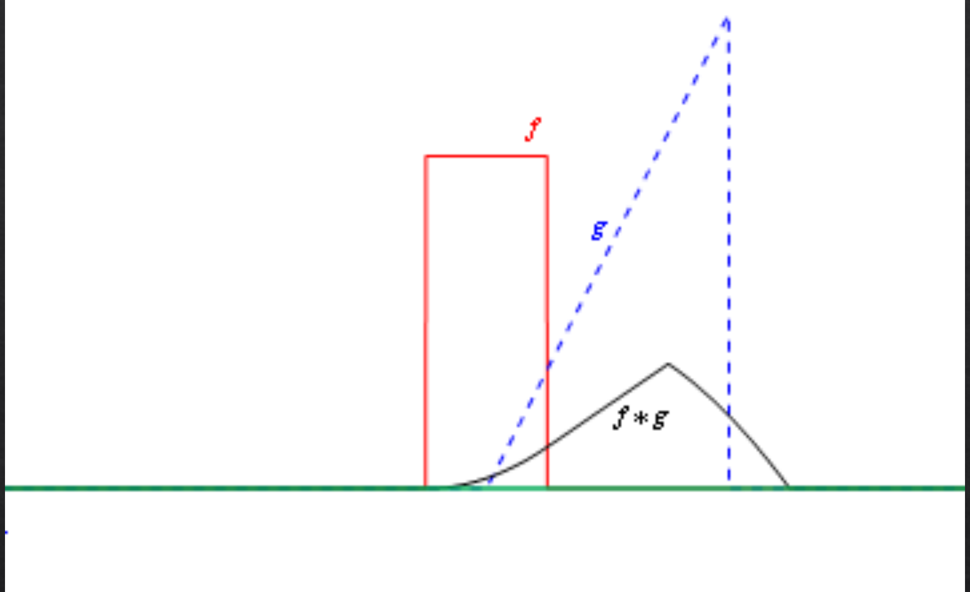
Sums of weighted, shifted functions!



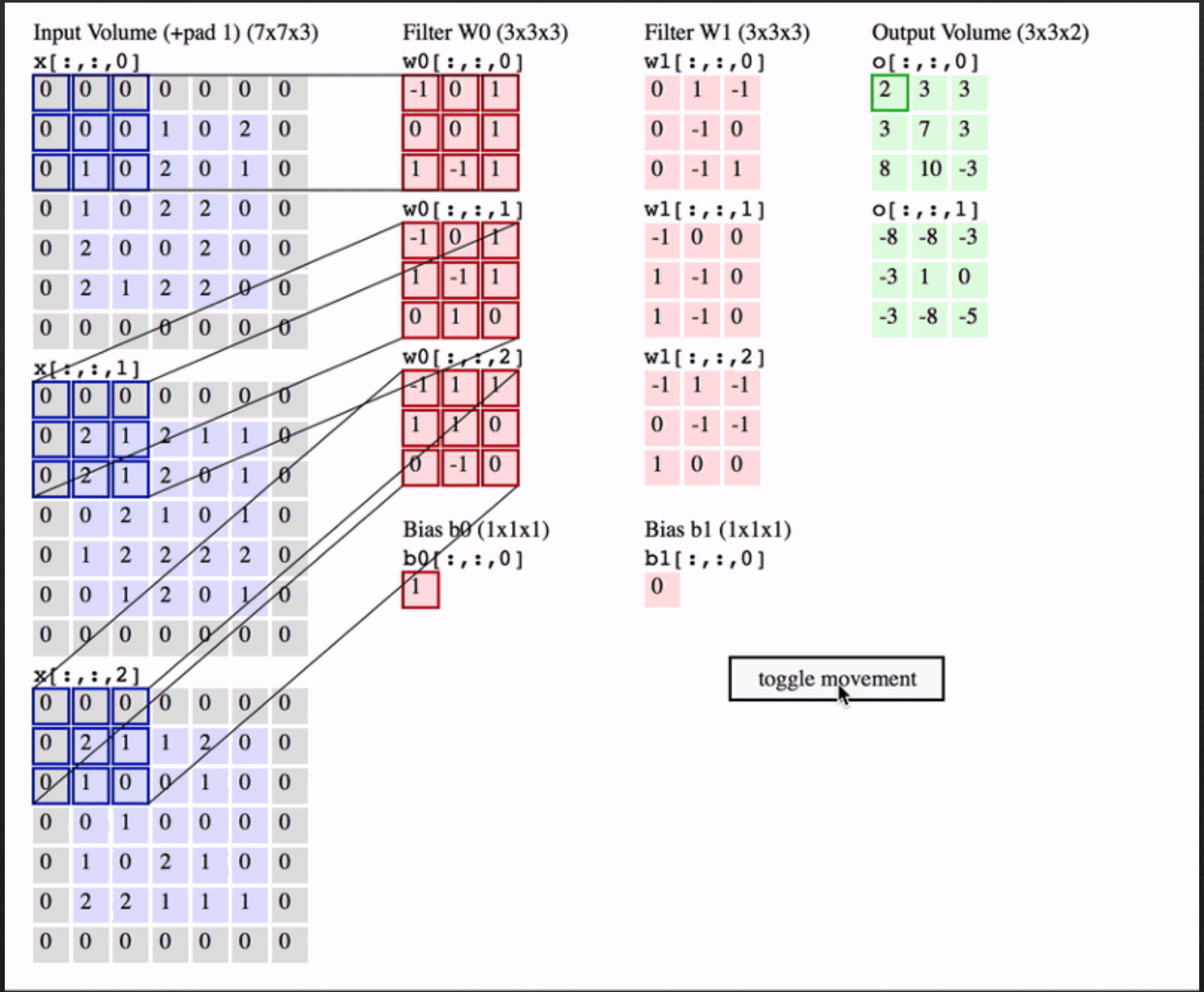
1D convolution



Sums of weighted, shifted functions!



2D convolution



https://www.freecodecamp.org/news/an-intuitive-guide-to-convolutional-neural-networks-260c2de0a050/

Blurring due to integrals in rendering

- area lights
- camera lens
- camera shutter, exposure time
- wavelength (colour spectrum)
- gloss (reflectance)
- translucent objects

$$\int f(x-t)\, g(t)\, dt$$

$$\approx \sum$$