

Source: [KBPhysicsMasterIndex](#)

# 1 | Quantum Mechanics

**What is quantum mechanics?** Quantum => in small/discrete steps

The Quantum of US Currency => \$0.01

## 1.1 | Puzzle of the Blackbody Radiation

("black" => opaque): from solid materials, liquids

The radiation from hot, solid materials looks samey (bright yellow) unlike every gas, however, had a spectral emission (think - neon lights.)

But!

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The light spectrum did depend on temperature, so what happened? Why is everything hot?

**Max Plank** => trying to model incoming light source from rays as basically all absorbed and not bounced back.

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Max Plank's Model 1 in this manner matched well with observations at long wavelengths (red hot). But, it predicted infinite brightness (it will just "keep bouncing") as wavelength => 0, which is wrong. This is the "ultraviolet catastrophe."

So, he made it better.

Max Plank's Model 2 is just Model 1, but an additional assumption that when Energy Transfers from  $e^-$  to EMWave,  $\delta E$  must be some constant \* frequency of light.

So, to synthesize high frequencies, this cop out had the effect of suppressing the infinite growth as  $\delta E$  would grow bigger and bigger to the point where all your energy would not go into the EMWave but to this transferring factor.

Which is like... Kind of a cop out. But it did fit medium frequencies better.

Einstein => Light != "wave"; instead, light are photon particles moving through space.

**Important Knowledges::**

Energy of each photon is equal to the plank constant (h) times the frequency (f).  $E = h * f$ .

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$$\lambda * f = c$$

$$E_{\text{photon}} = h \times f$$

Instead of Hertz, however, the frequency of F could better be represented with  $\omega$ , a unit of  $\frac{\text{radians}}{\text{sec}}$  that is derived as  $2\pi f(\frac{\text{radians}}{\text{s}})$

So to calculate energy with  $\omega$ , simply use  $\bar{h} = \frac{h}{2\pi}$  and so  $E = \bar{h}\omega$

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## 1.2 | Heisenberg Uncertainty

$\Delta E \times \Delta t = \hbar \Rightarrow$  “uncertainty of energy times uncertainty in time is the reduced plank’s constant”

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Lifetime of the upper level  $\Rightarrow \Delta t$

(Mean) lifetime of the “upper” energy level  $\Rightarrow \Delta t$ . So,  $\Delta E = \frac{\hbar}{\Delta t}$ .

If  $\Delta t$  is small,  $\Delta E$  is large.

As long as the units of two deltas end up as  $J \times s$ , they would be related by the same way with  $\hbar$

This  $\Delta P$  has an actual effect on our vision

**THIS IS IMPORTANT, TOO!**  $\Delta \vec{p} \times \Delta \vec{x} \approx \hbar$ .

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Meaning, in the subatomic world, everything exists based on differencing upper-energy-state-time based uncertainties.

“Diffraction through an aperture”

We could see a similar pattern in passing photons through a slit. *Slit large,  $\Delta P_x$  small Slit small,  $\Delta P_x$  large.*

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This limits the width of the lens of a camera because of the uncertainty in momentum.

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Taking the angle, and dividing it by 3000, which is  $\frac{1}{60}$  degrees.

Even though Plank’s constant is a tiny number, it effects how sharply you eyes could see b/c of this uncertainty.

There are three “flavor”s of Leptons, each with two variations — creating six different leptons.

Lepton  $\Rightarrow$  “small”, but they are not actually that small as what their original namer had suggested.

## 1.3 | Famous Leptons

- The Electron
  - Dirac’s equations predicted the existance of a certain “positron” which would be the opposite of an electron. After self-determination (the “equation was too perfect to be wrong”), he set out hard to try to prove it.

**Interactions in the small scale world occur through the creation and annihilation of particles.**

Neutrinos interact only by weak interactions, which is (bar gravity, which is the weakest physical interaction) a very weak physical interaction.

Pions and Muons are two pairtcles