Physics for Game Developers

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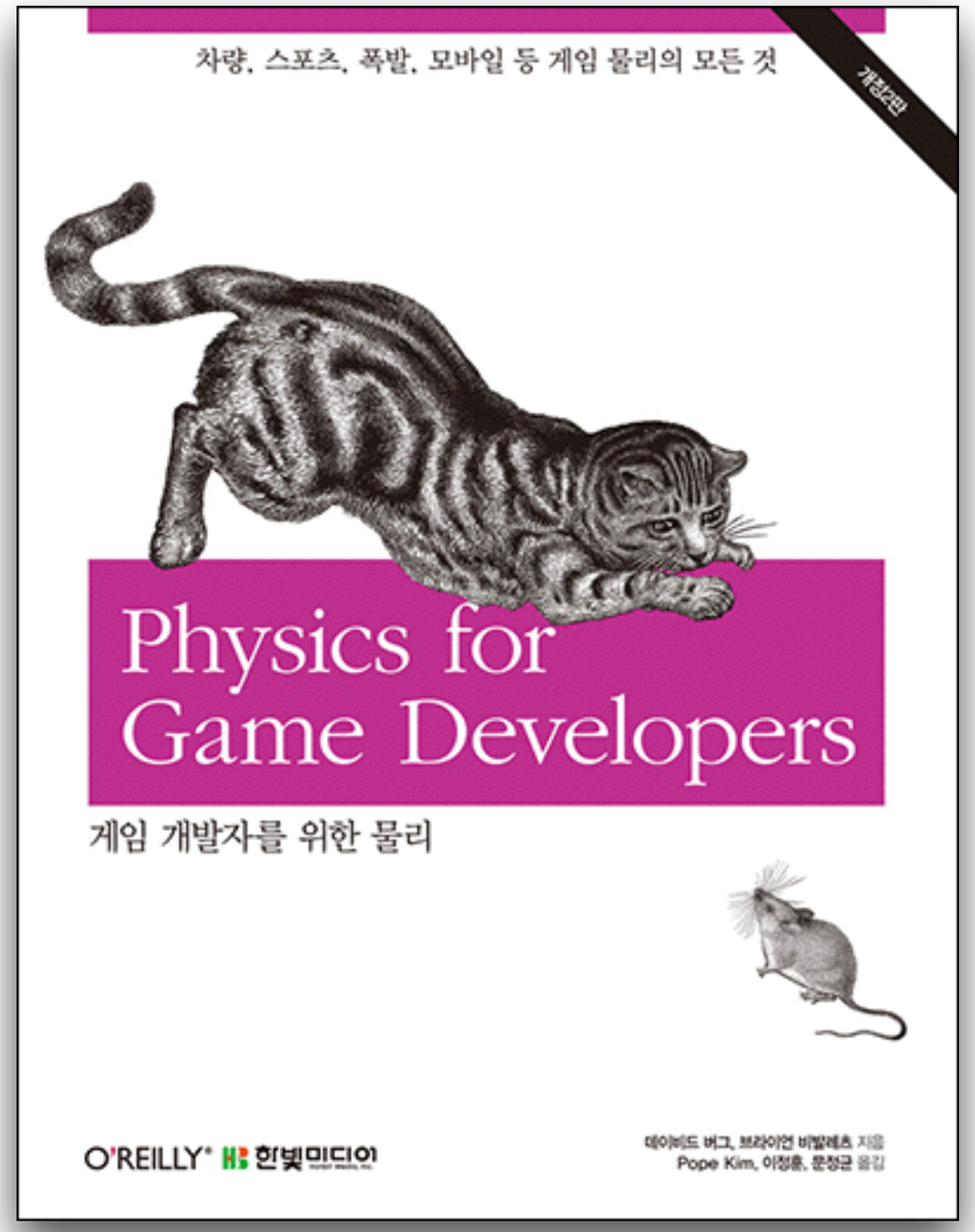
Required Text



Lecture Info

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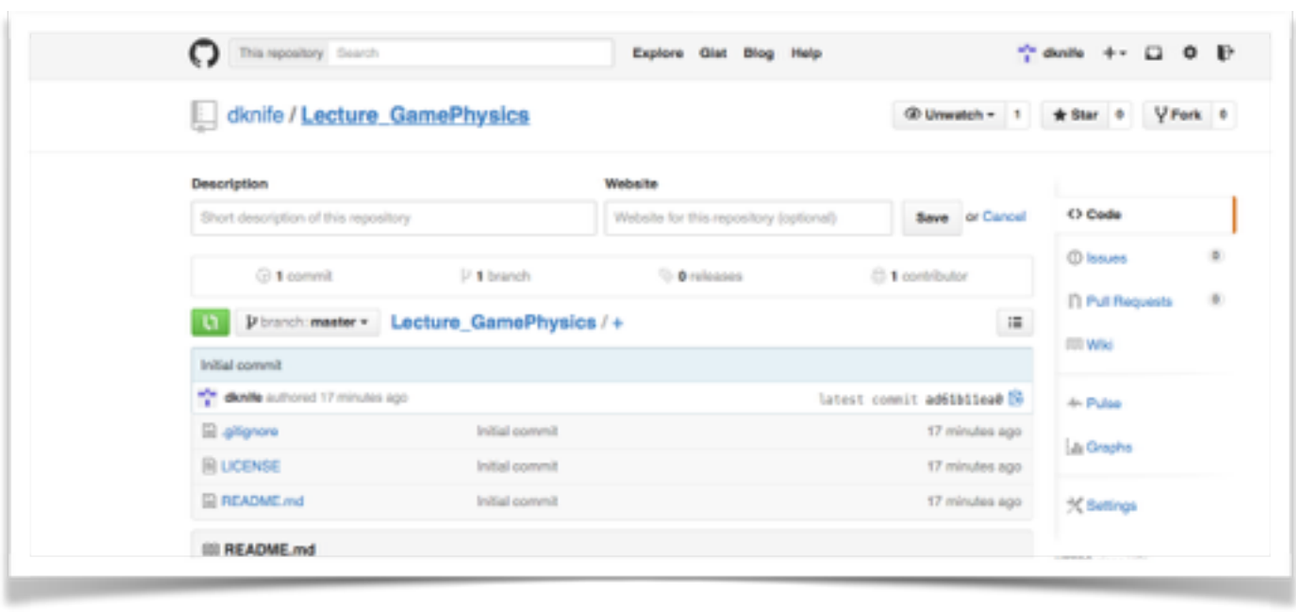
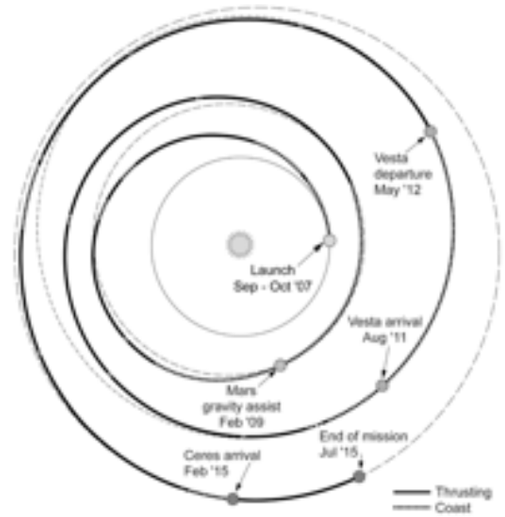
- Lecture Materials are available at
    - Lecture homepage: http://210.110.195.15
    - GitHub: https://github.com/dknife/Lecture_GamePhysics



Why is Physics needed?

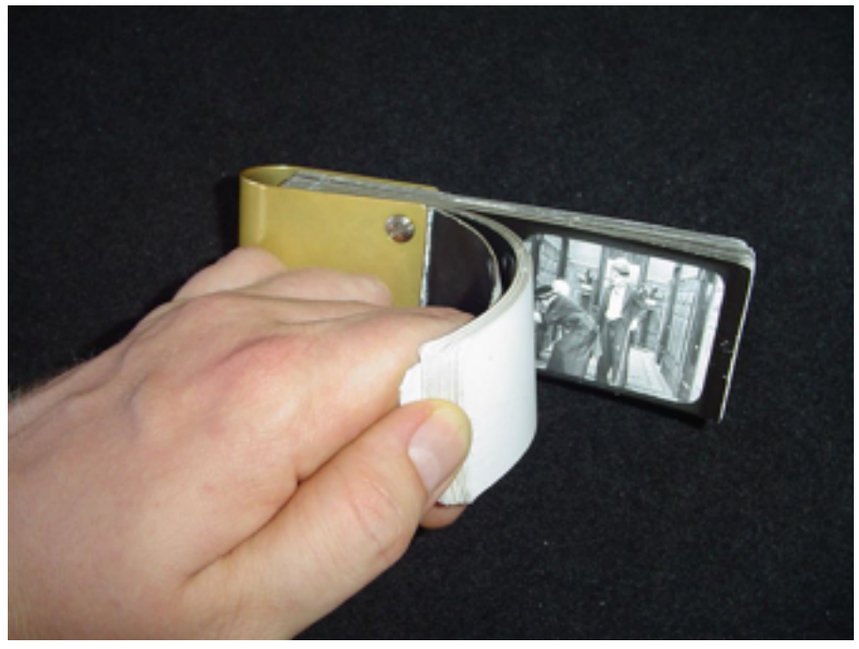
- Game
  - based on Computer Graphics
    - Modelling, Animation, and Rendering

- Plausible (realistic) Animation
  - requires “physically correct” motion



Animation

- Animation
  - consecutive images
  - illusion of motion
  - change over time



- What can be changed
  - position, scale, colour, and any other *visual* properties
  - quantities of changing properties
    - functions of “time”

Computer animation

- Computer-aided animation
  - what will actually computer help?
    - computing…
      - the motion based on dynamics: simulation
      - the motion based on kinematics
      - interpolated values between keys: keyframe animation

Physics basics

- Newton
  - a super hero in physics
    - "*Philosophiae Naturalis Principia Mathematica*"
  - Newton's laws
    - 1: Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it
    - 2: The relationship between an object's mass m, its acceleration $\mathbf{a}$, and the applied force $\mathbf{F}$ is $\mathbf{F}=m\mathbf{a}$.
    - 3: for every action there is an equal and opposite reaction.

units

- International System of Units (SI)
  - Why called SI?
    - Le **S**ystème **I**nternational d'Unités
  - mass: kg
  - length: m
  - time : s
  - velocity: m/s (derived unit)
  - acceleration: m/s^2 (derived unit)
  - force: $kg\ m/s^2 = N$ (derived unit)

units

- base units

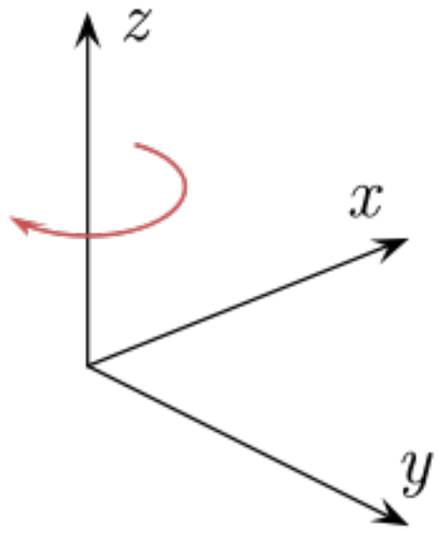
SI base units

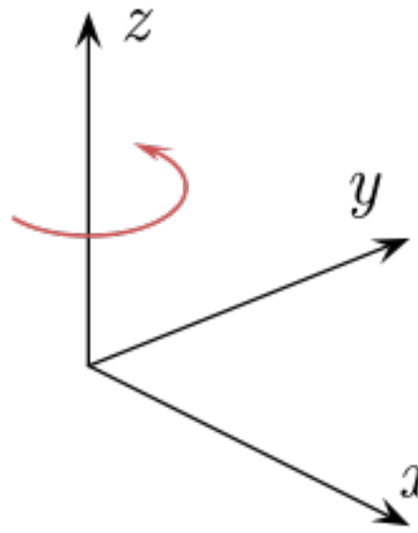
Name	Symbol	Measure	Current (2005) formal definition[1]	Historical origin / justification	Dimension symbol
metre	**m**	length	"The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second." *17th CGPM (1983, Resolution 1, CR, 97)*	1/10,000,000 of the distance from the Earth's equator to the North Pole measured on the circumference through Paris.	L
kilogram	**kg**	mass	"The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram." *3rd CGPM (1901, CR, 70)*	The mass of one litre of water. A litre is one thousandth of a cubic metre.	M
second	**s**	time	"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom." *13th CGPM (1967/68, Resolution 1; CR, 103)* "This definition refers to a caesium atom at rest at a temperature of 0 K." *(Added by CIPM in 1997)*	The day is divided in 24 hours, each hour divided in 60 minutes, each minute divided in 60 seconds. A second is 1/(24 × 60 × 60) of the day	T
ampere	**A**	electric current	"The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length." *9th CGPM (1948)*	The original "International Ampere" was defined electrochemically as the current required to deposit 1.118 milligrams of silver per second from a solution of silver nitrate. Compared to the SI ampere, the difference is 0.015%.	I
kelvin	**K**	thermodynamic temperature	"The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water." *13th CGPM (1967/68, Resolution 4; CR, 104)* "This definition refers to water having the isotopic composition defined exactly by the following amount of substance ratios: 0.000 155 76 mole of ^{2}H per mole of ^{1}H, 0.000 379 9 mole of ^{17}O per mole of ^{16}O, and 0.002 005 2 mole of ^{18}O per mole of ^{16}O." *(Added by CIPM in 2005)*	The Celsius scale: the Kelvin scale uses the degree Celsius for its unit increment, but is a thermodynamic scale (0 K is absolute zero).	Θ
mole	**mol**	amount of substance	"1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is 'mol.' 2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles." *14th CGPM (1971, Resolution 3; CR, 78)* "In this definition, it is understood that unbound atoms of carbon 12, at rest and in their ground state, are referred to." *(Added by CIPM in 1980)*	Atomic weight or molecular weight divided by the molar mass constant, 1 g/mol.	N
candela	**cd**	luminous intensity	"The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian." *16th CGPM (1979, Resolution 3; CR, 100)*	The candlepower, which is based on the light emitted from a burning candle of standard properties.	J

Coordinate System

- Coordinate systems
  - Refer to Game Math Lecture
  - http://210.110.195.15/projects/prof_kang_lecture_2014_2/wiki/201402_게임수학
- We will use
  - right-handed Cartesian coordinate system

left-handed

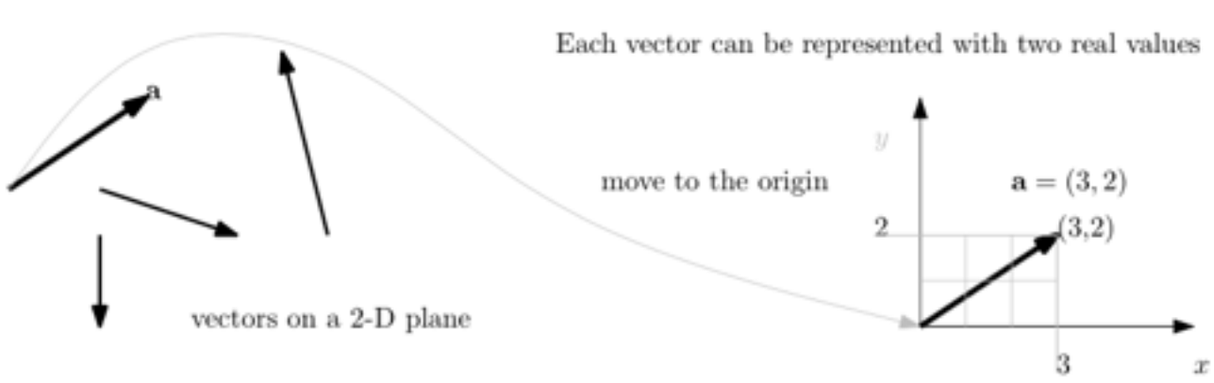


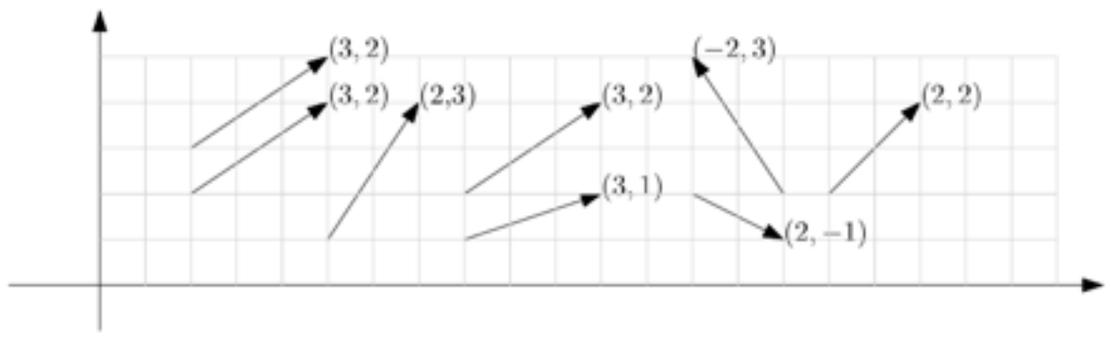


right-handed

Vector

- Vector
  - Refer to Game Math Lecture
  - http://210.110.195.15/projects/prof_kang_lecture_2014_2/wiki/201402_게임수학





Calculus

- Calculus is very important
- But… Don’t worry
  - We just need understand the concept
    - velocity is the change of distance during a small time period

$$|\mathrm{v}| = \frac{d\mathrm{s}}{dt} \qquad\qquad s = \int \mathrm{v}(t)dt$$

Mass and Moment of Inertia

- Mass
  - resistance to being accelerated by force
- Moment of Inertia
  - resistance to angular acceleration by torque

very important when computing motion

moment of inertia is easily changed

What will be dealt?

- particles and rigid bodies
- linked objects