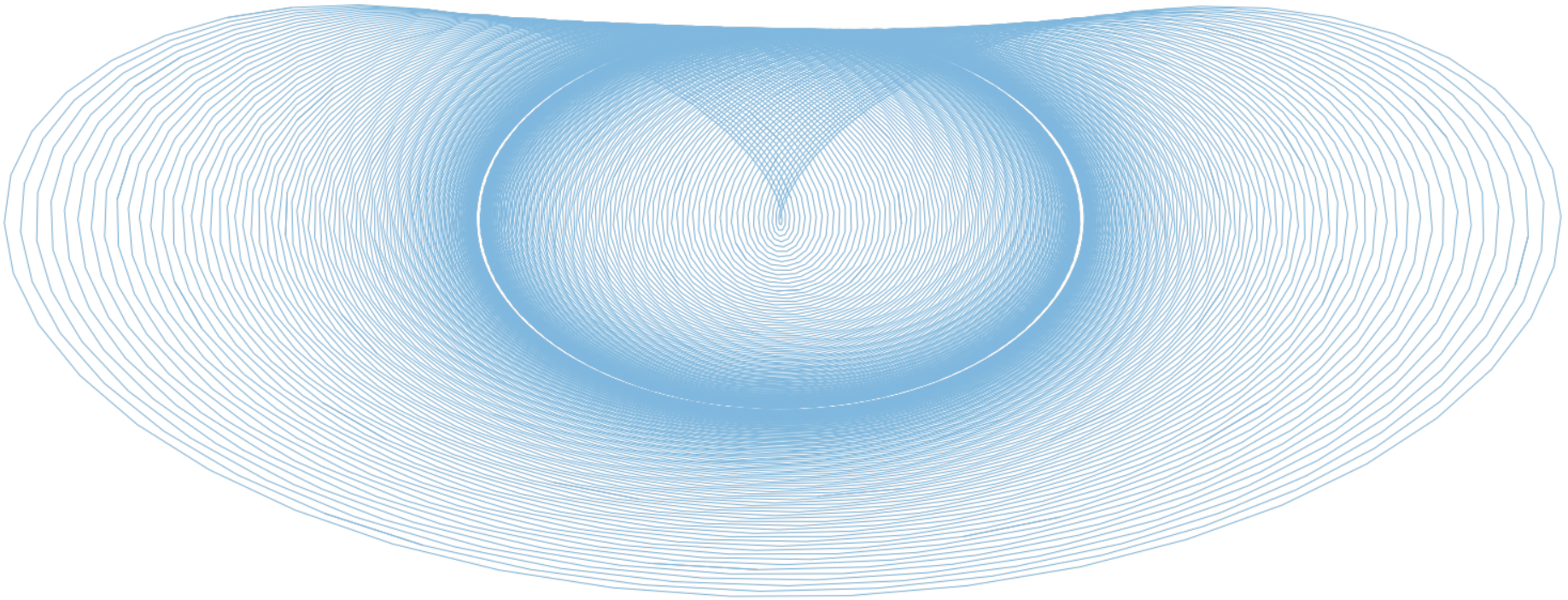
PHYS 1420 (F19)
Physics with Applications to Life Sciences



2019.09.11

Relevant reading:
Kesten & Tauck ch.2.4

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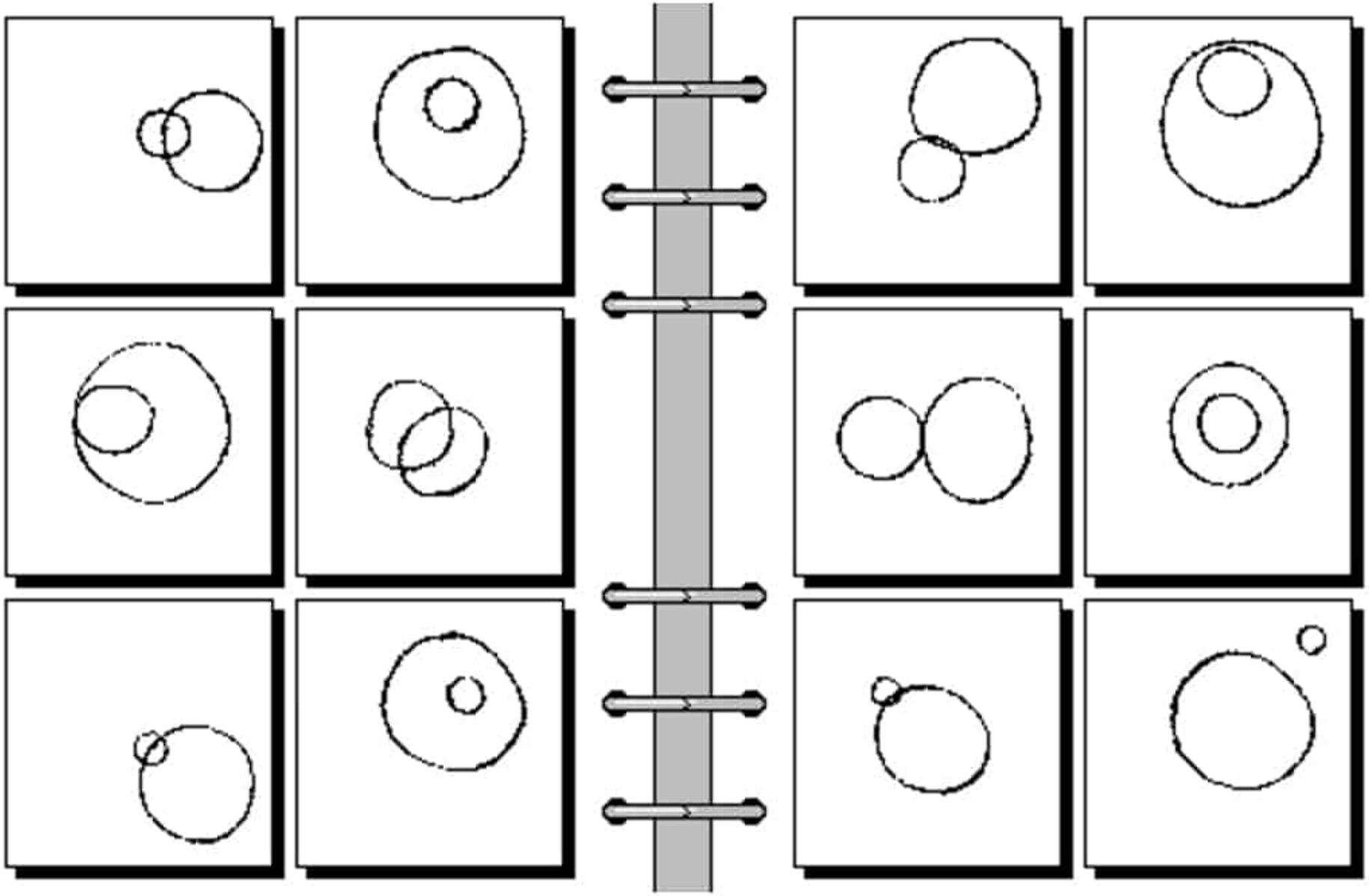
Ref. (re images):
Wolfson (2007), Knight (2017)



Announcements & Key Concepts (re Today)

→ Integrated Science (ISCI) program:
http://science.yorku.ca/future-students/integrated-science/

→ (online) HW deadlines

→ Labs: Start next week! (Sept.16-20)
https://www.yorku.ca/menary/courses/firstyrlabs/2019/main.html

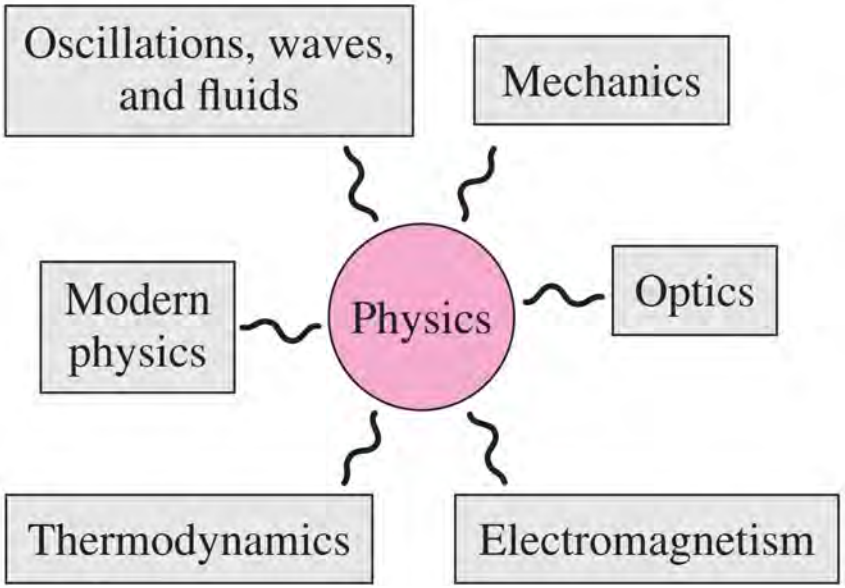
Some relevant underlying concepts of the day…

- What is *gravity*?
- 1-D motion due to gravity
- Examples

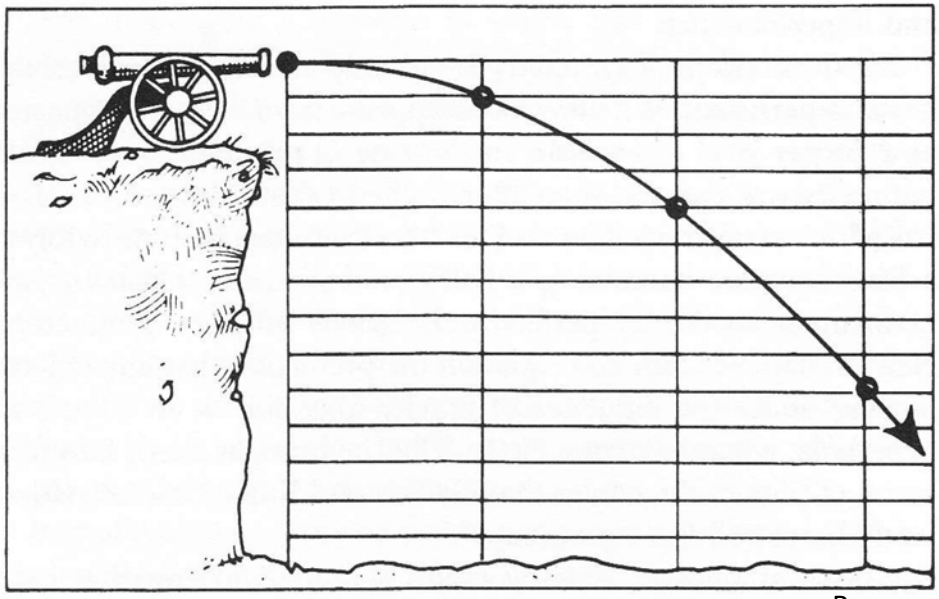
Mechanics

- What is/are “mechanics”?

“Mechanics (Greek μηχανική) is an area of science concerned with the behaviour [sic] *of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment.”*



e.g., “classical mechanics”



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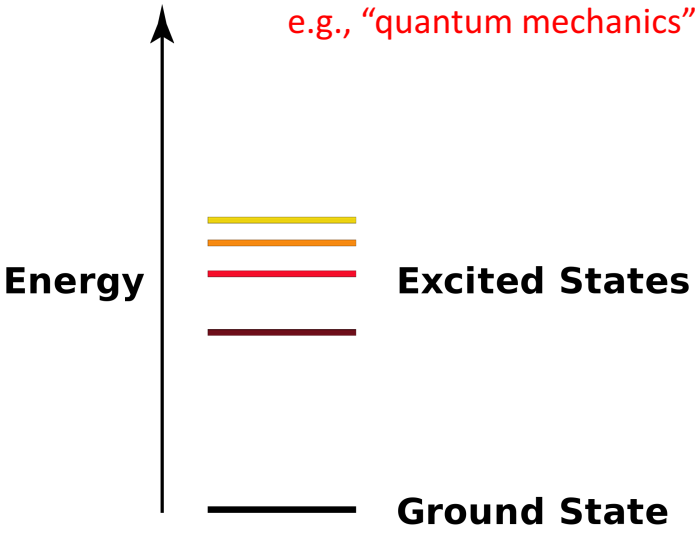
e.g., “quantum mechanics”

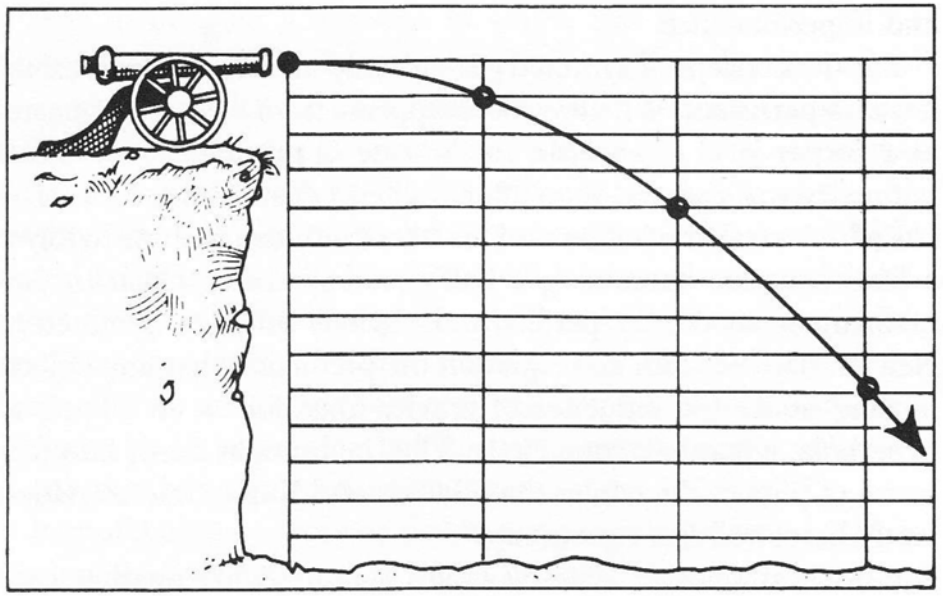


Wikipedia (Mechanics)

Niccolò Tartaglia (1499-1557)

Question: What angle of elevation would a cannon achieve its greatest range?

"Tartaglia's correct theoretical answer of 45° surprised the experts; they thought it would be smaller [...] but he refrained from publication. The reason for his diffidence is highly creditable: He felt it would be immoral to use science to help [soliders] slaughter [soliders] more efficiently"



→ As we will see later on, 45° is not technically correct for "real" cannonballs....

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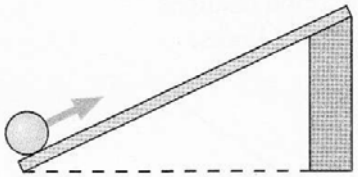
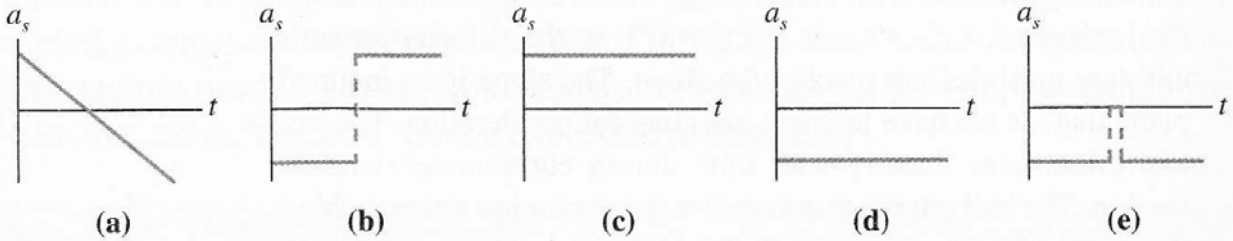
Ex.

STOP TO THINK 2.5 The ball rolls up the ramp, then back down. Which is the correct acceleration graph?



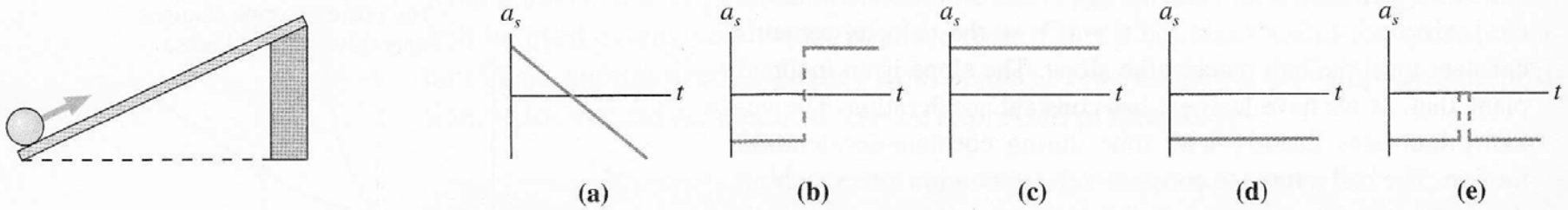


→ For "1-D" problems (considering 2-D scenarios), make sure to be smart about sign conventions and whanot…

Knight

Ex.

STOP TO THINK 2.5 The ball rolls up the ramp, then back down. Which is the correct acceleration graph?



→ Gravity works in a consistent "downward" fashion (and is typically treated within the context of problems involving "constant acceleration"

Aside: What causes gravity?

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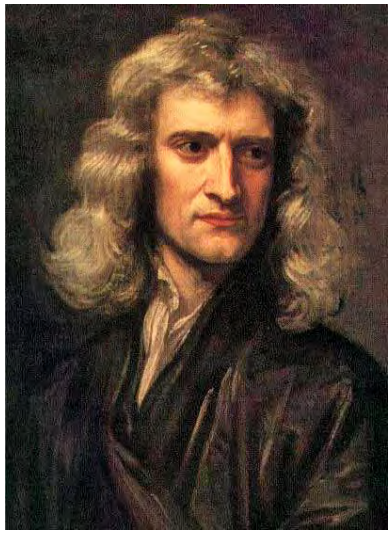
Aside: What causes gravity?

Mechanism for "action at a distance?"



Gravitational attraction between two bodies (e.g., apple falling to earth)

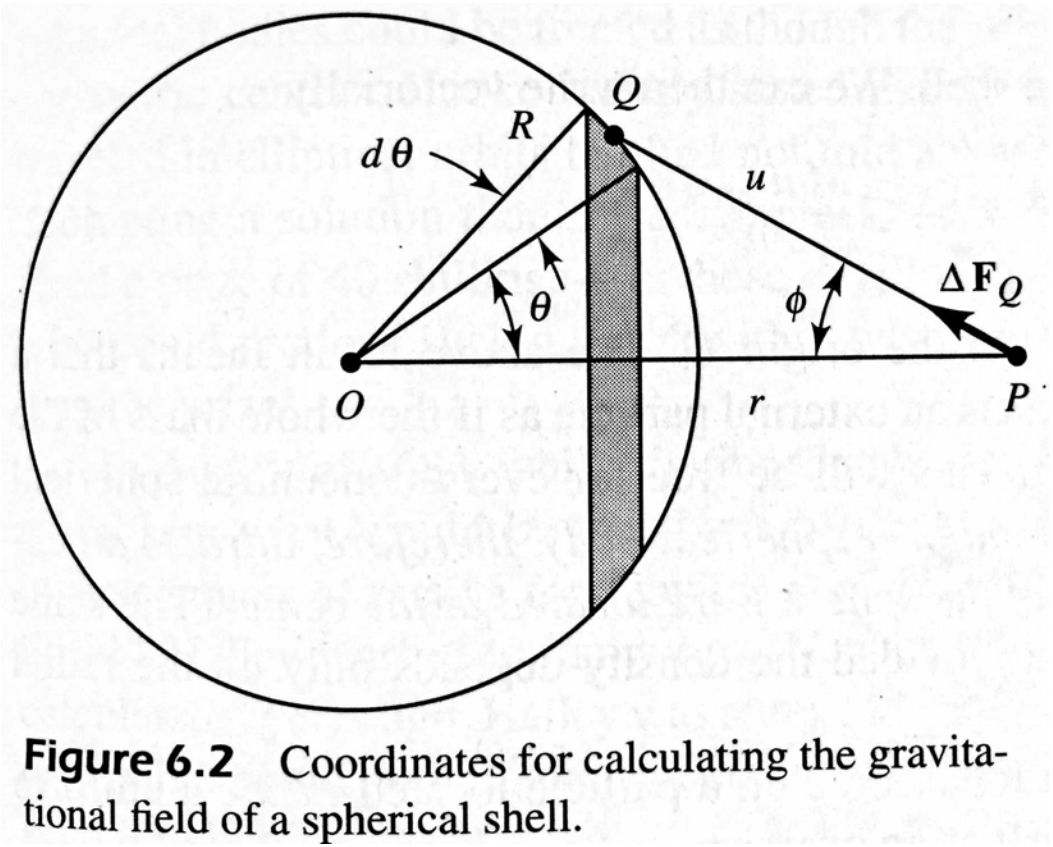


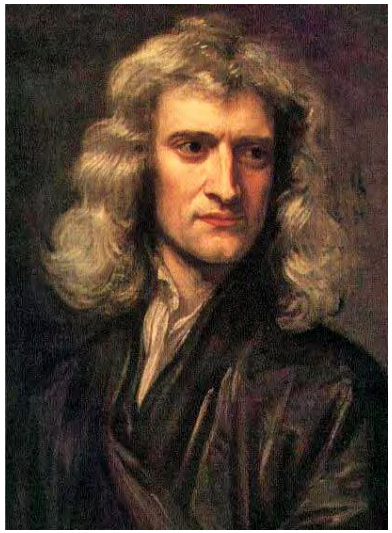
Figure 6.2 Coordinates for calculating the gravitational field of a spherical shell.

→ Leads to the familiar 9.8 m/s^2 for earth's gravity (and why it is assumed const.)

Knowles & Cassidy

Aside: What causes gravity?

Mechanism for "action at a distance?"

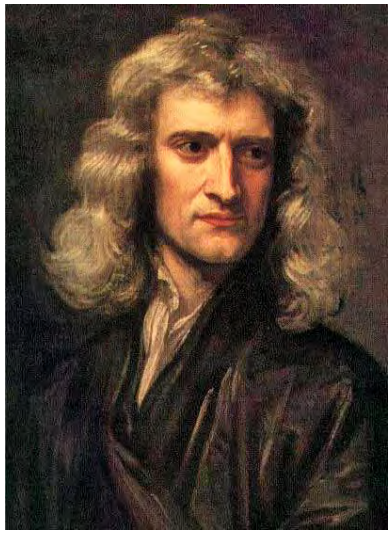


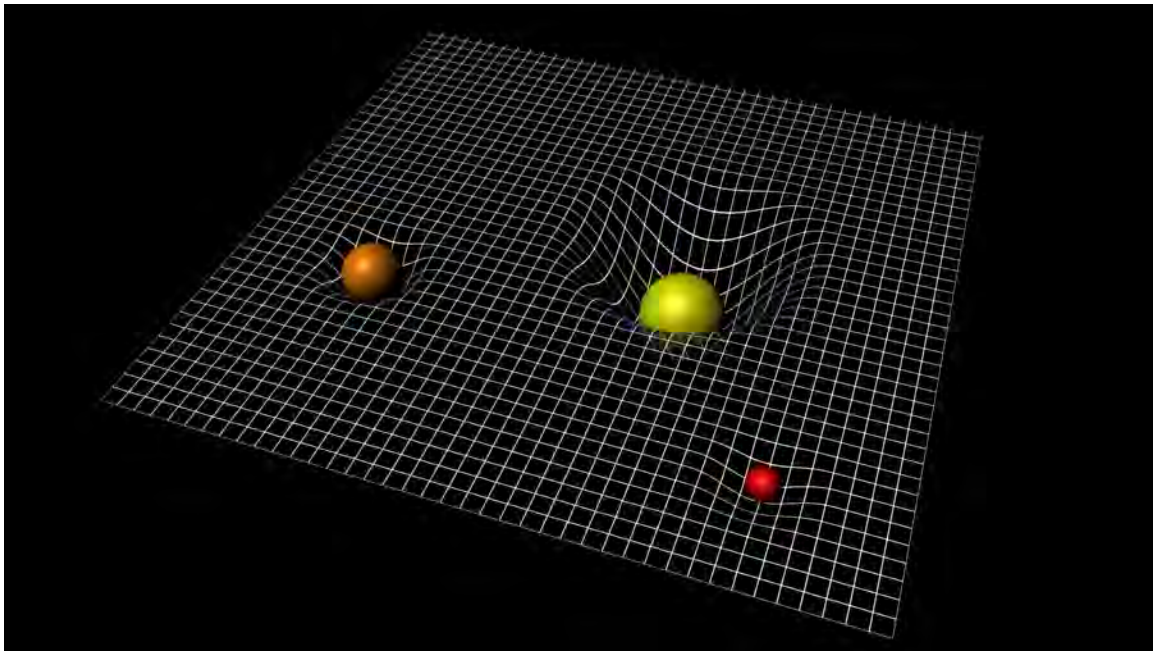
York's "Newton tree"
(grown from a cut sapling of Newton's original tree!)

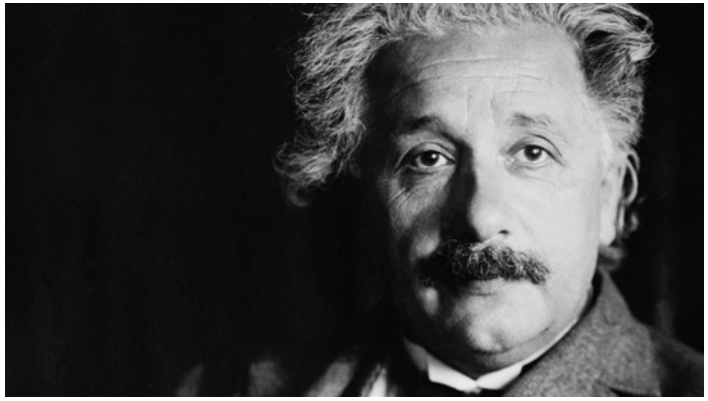
http://news.yorku.ca/2005/10/19/rare-%E2%80%9Cnewton%E2%80%99s-apple-tree%E2%80%9D-bears-fruit-for-first-time/
http://www.gettyimages.ca/detail/news-photo/newton-apple-toronto-ontario-sir-isaac-newtons-apple-tree-news-photo/165283797#newton-apple-toronto-ontario-10192005sir-isaac-newtons-apple-tree-at-picture-id165283797

Aside: What causes gravity?

Mechanism for "action at a distance?"

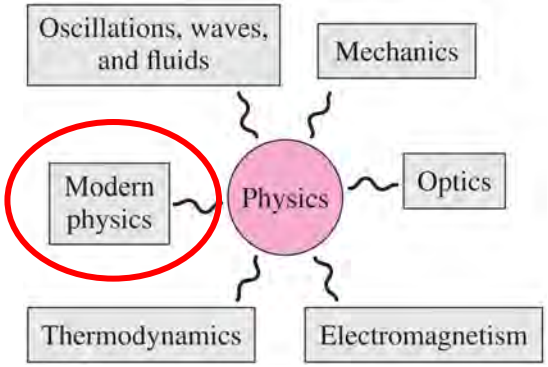






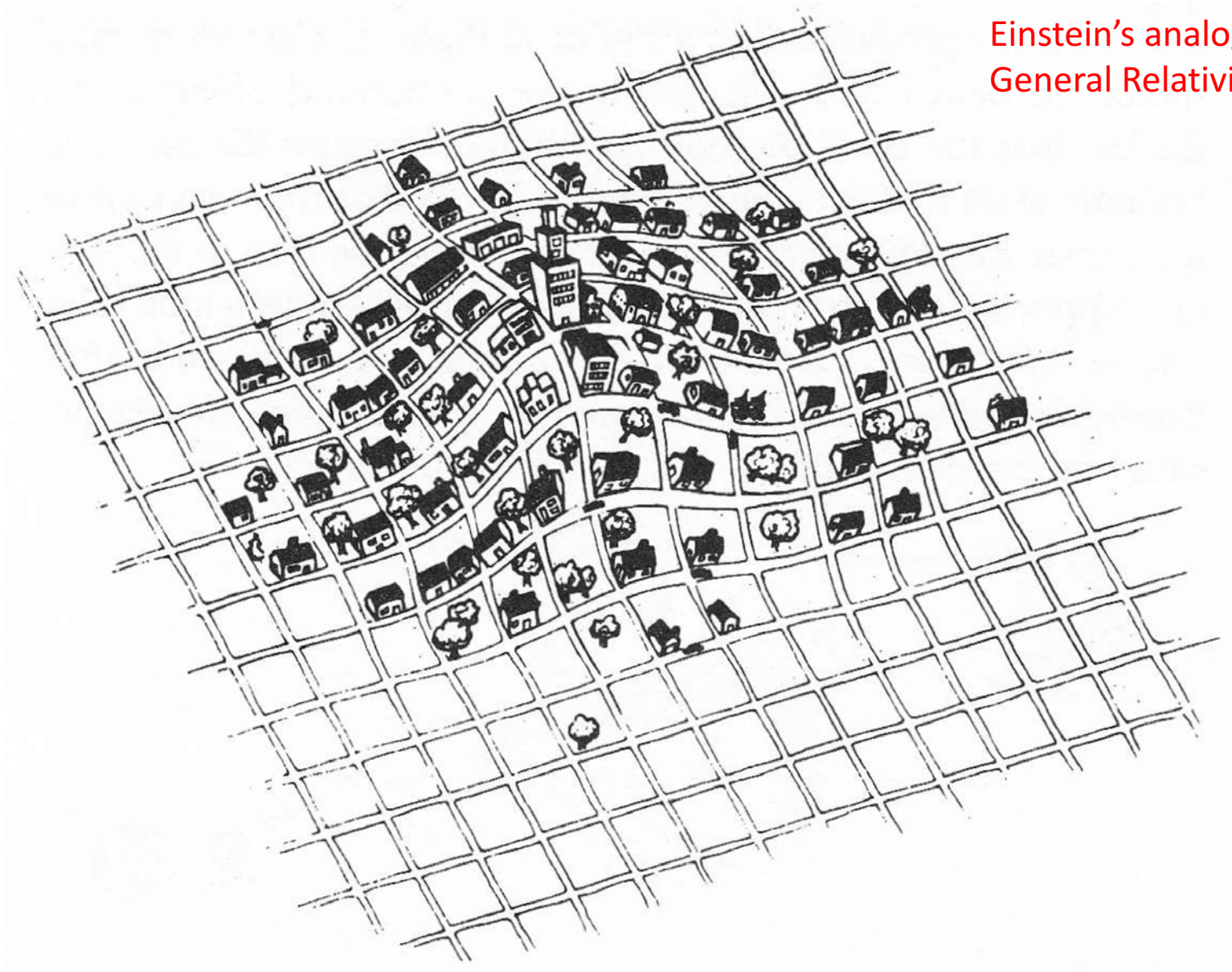
http://www.pbs.org/wgbh/nova/physics/einstein-big-idea.html

General relativity → "Notion of spacetime"



http://sci.esa.int/lisa-pathfinder/56909-100-years-of-general-relativity/

Aside: What causes gravity?

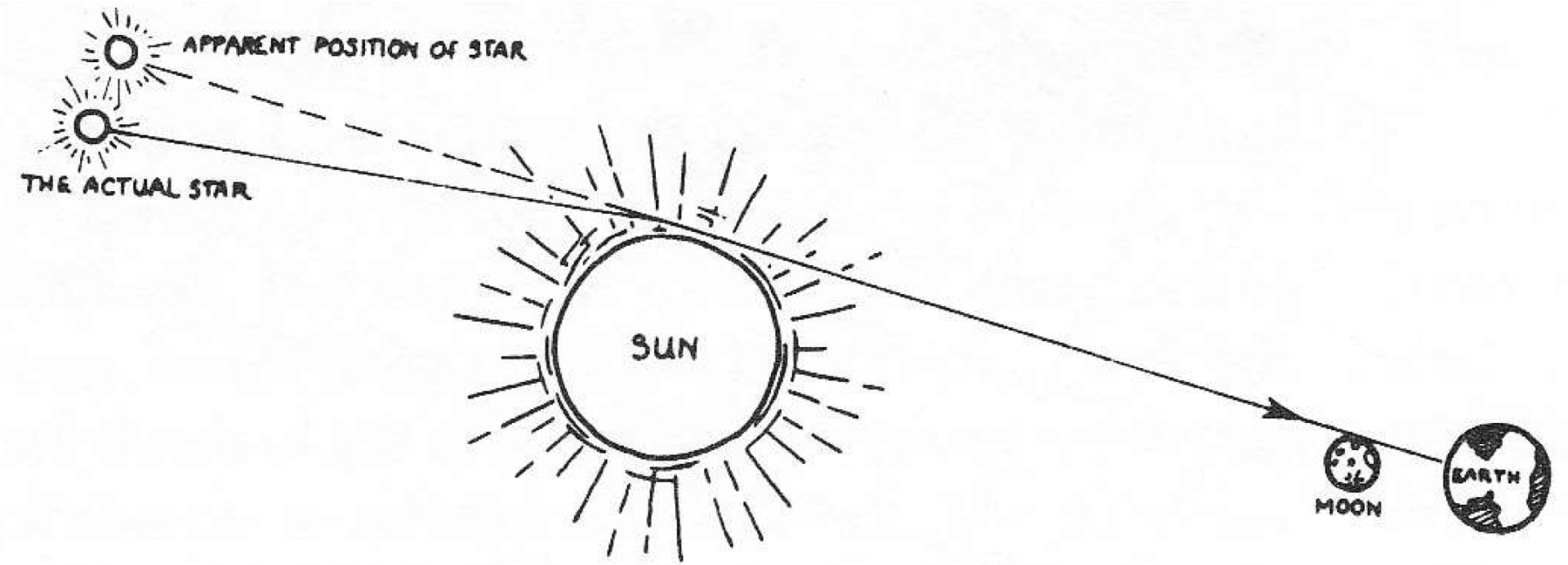


Einstein's analogy for General Relativity

von Baeyer

Aside: What causes gravity?

A testable prediction stemming from Einstein's theory of General Relativity



→ And it worked like a charm! Tested in Sept. 1919, Einstein became a rockstar afterwards!

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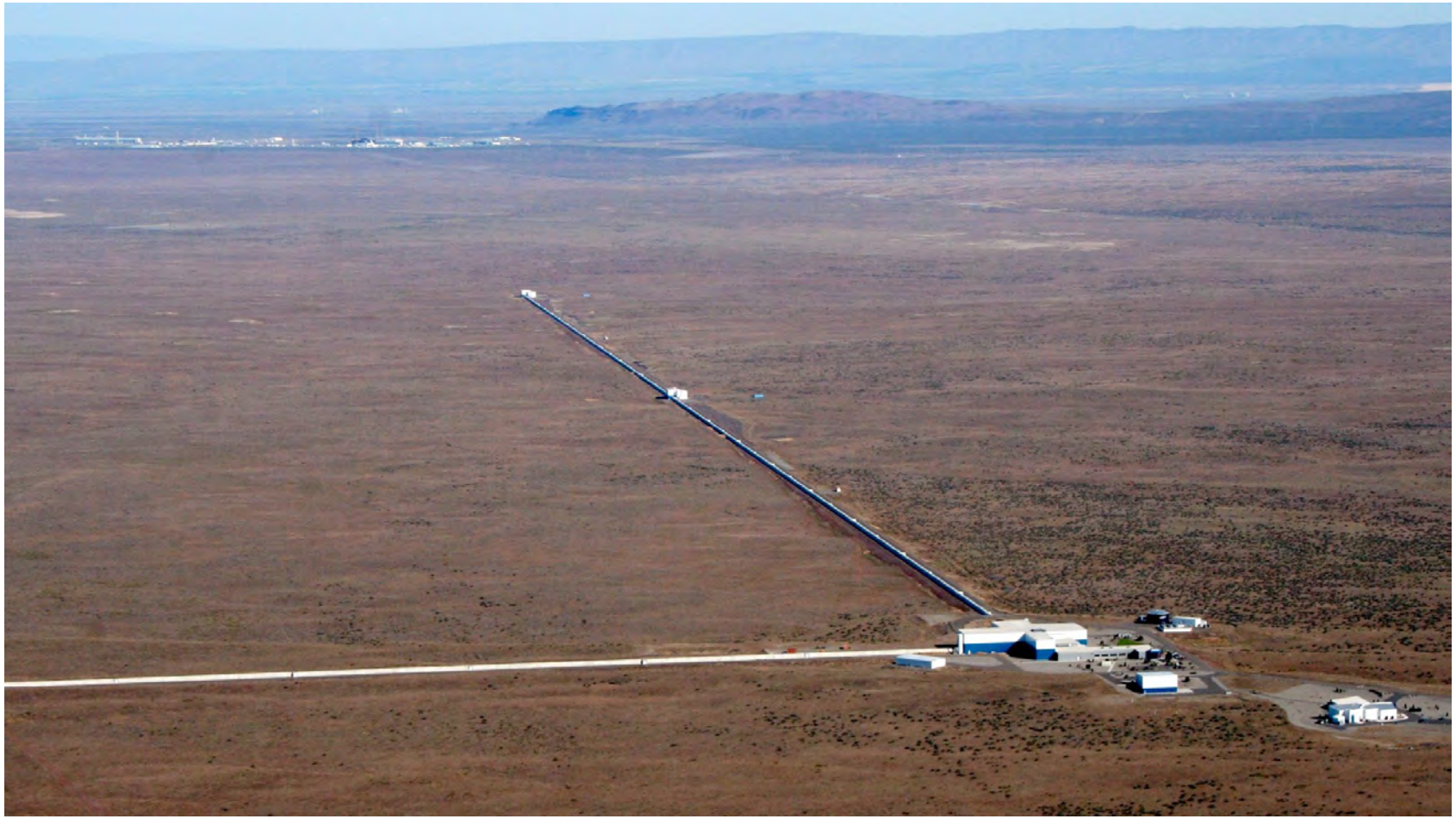
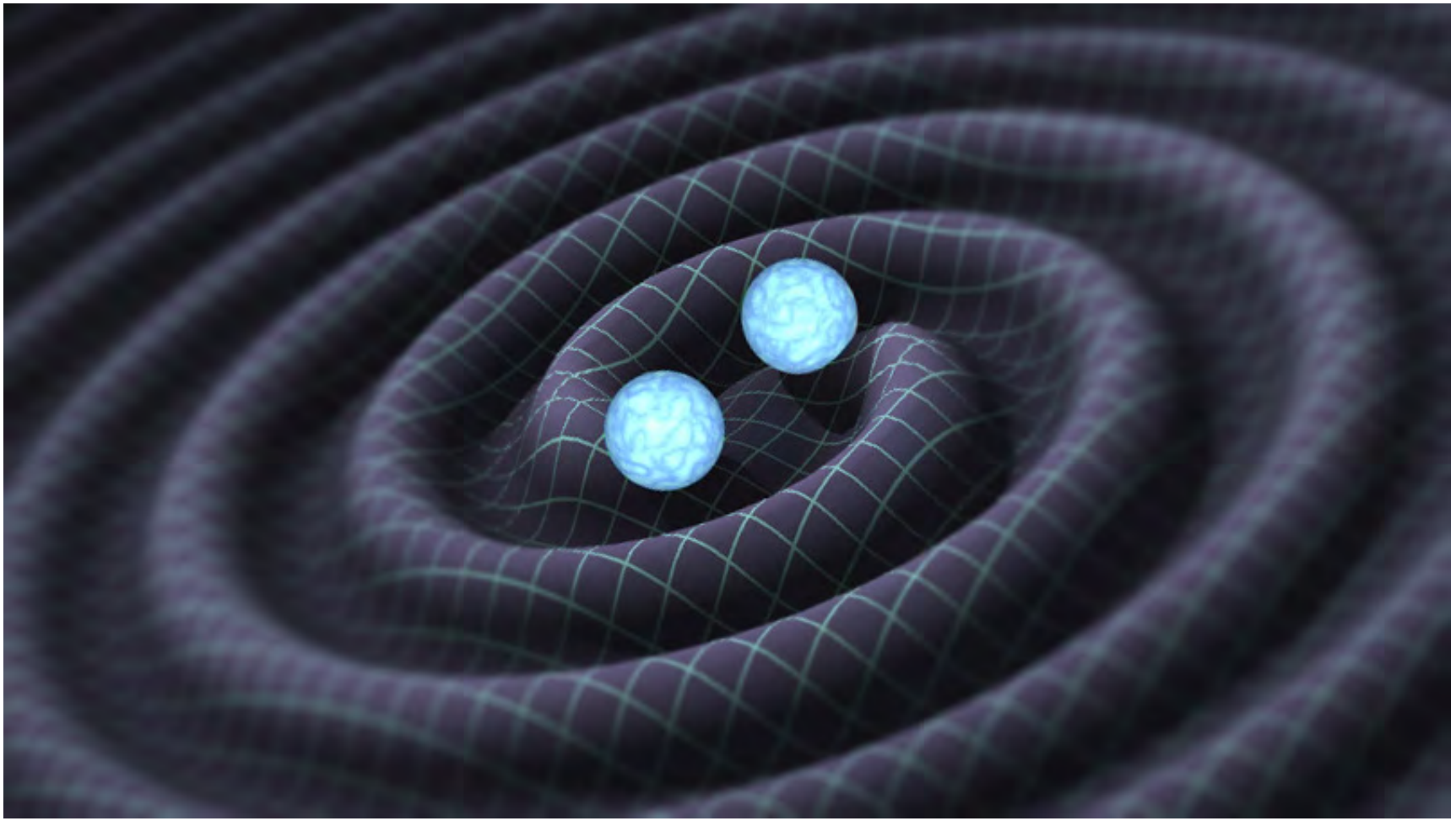
Aside: What causes gravity?

LIGO (=Laser Interferometer Gravitational-Wave Observatory)



http://www.pbs.org/wgbh/nova/next/physics/advanced-ligo/

Aside: What causes gravity?

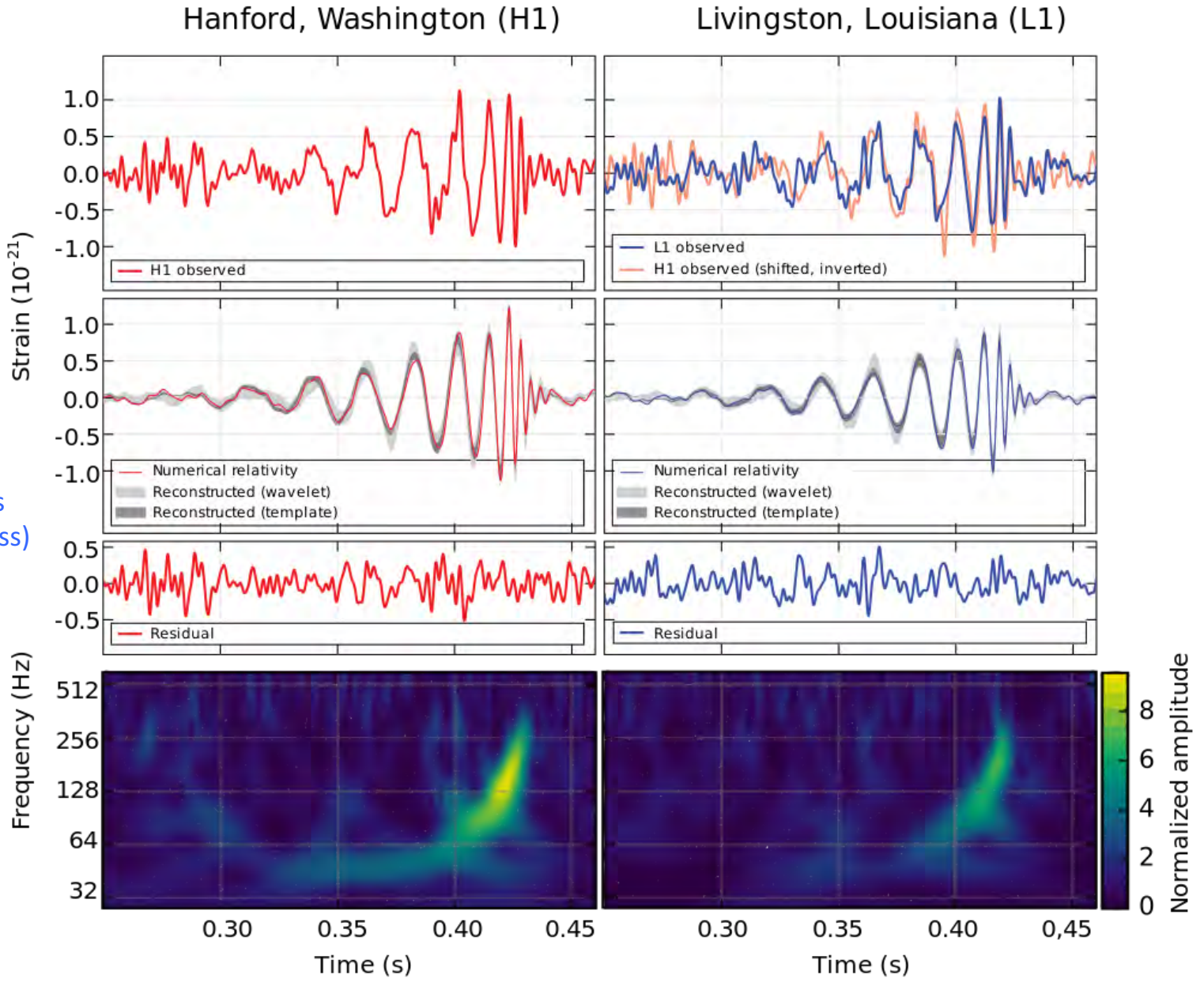


Two black holes collide and form a ripple in spacetime (→ Gravitational Waves)

https://www.ligo.caltech.edu/

"The event" occurred on Sept.14, 2015

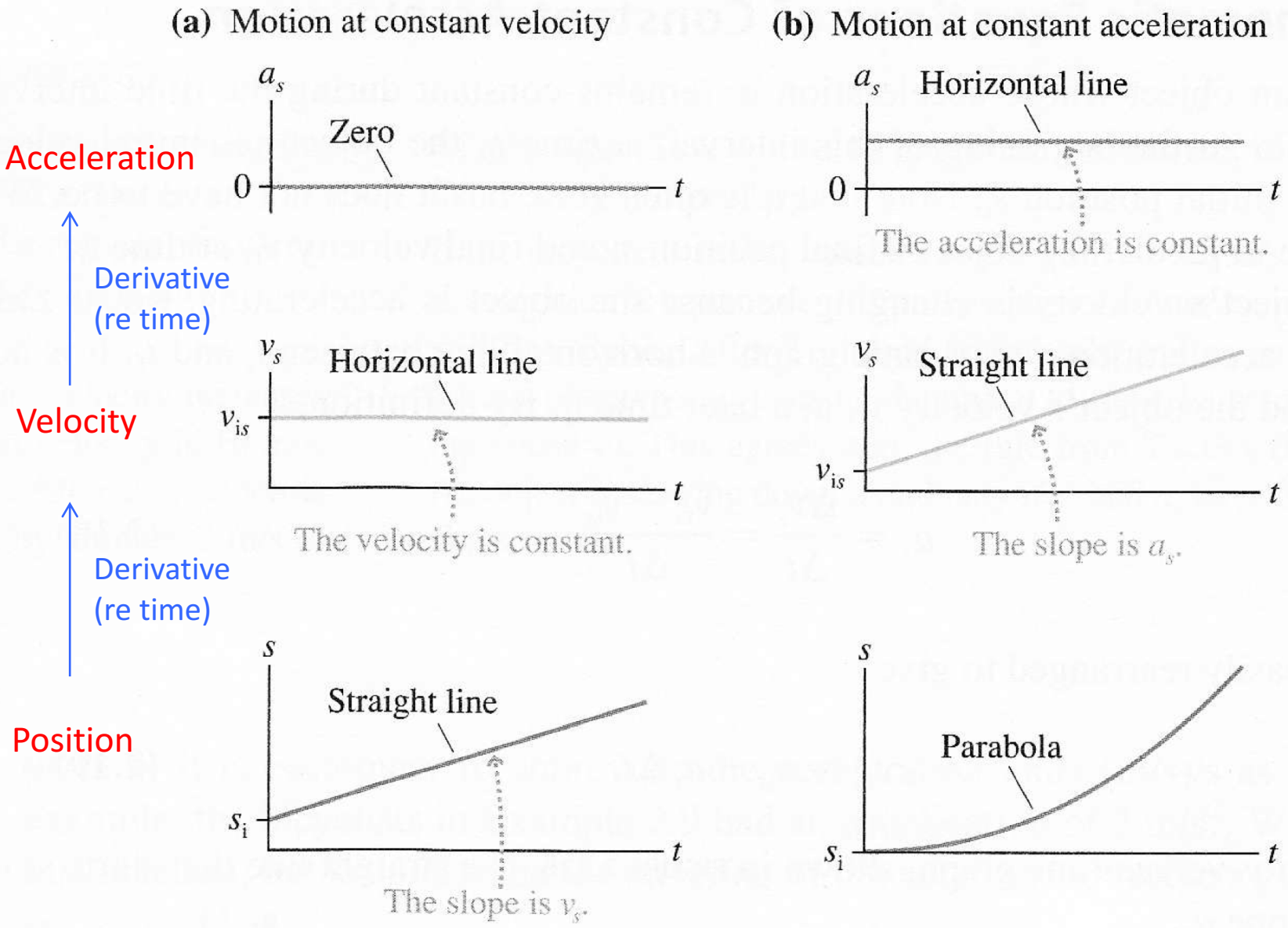
→ 2017 Nobel Prize went to LIGO founders (Thorne, Barish & Weiss)



→ Can listen to this! (https://www.youtube.com/watch?v=TWqhUANNFXw)

https://en.wikipedia.org/wiki/First_observation_of_gravitational_waves

FIGURE 2.24 Motion with constant velocity and constant acceleration. These graphs assume $s_i = 0$, $v_{is} > 0$, and (for constant acceleration) $a_s > 0$.



Knight

Table 2.1 Equations of Motion for Constant Acceleration

Equation	Contains	Number
$v = v_0 + at$	v, a, t; no x	2.7
$x = x_0 + \frac{1}{2}(v_0 + v)t$	x, v, t; no a	2.9
$x = x_0 + v_0 t + \frac{1}{2}at^2$	x, a, t; no v	2.10
$v^2 = v_0^2 + 2a(x - x_0)$	x, v, a; no t	2.11

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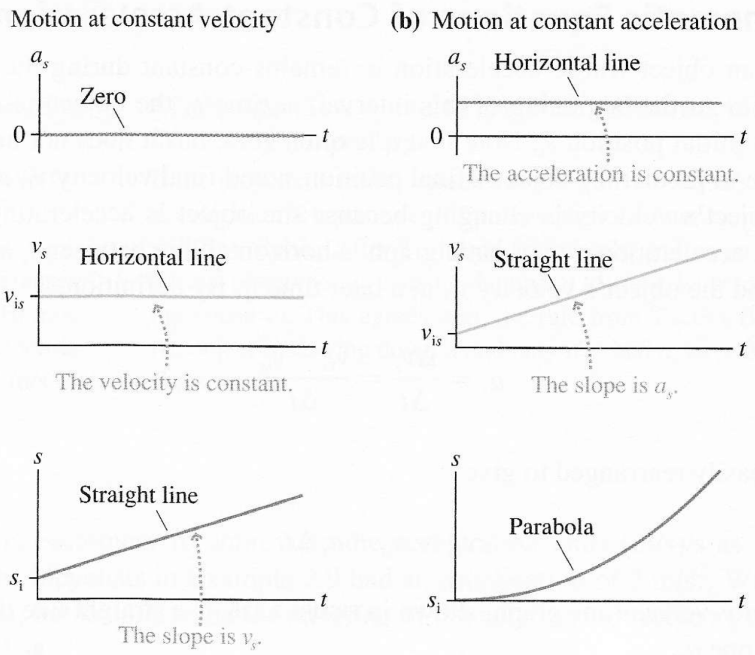


→ Convince yourself that these are two sides of the same coin!

The door swings both ways.....

Position, Velocity, and Acceleration

Derivative Form

If $s = s(t)$ is the position function of an object at time t, then

$$\text{Velocity} = v = \frac{ds}{dt} \qquad \text{Acceleration} = a = \frac{dv}{dt}$$

Integral Form

$$s(t) = \int v(t)\,dt \qquad v(t) = \int a(t)\,dt$$

Acceleration

Integrate (re time) ↓ ↑ Derivative (re time)

Velocity

Integrate (re time) ↓ ↑ Derivative (re time)

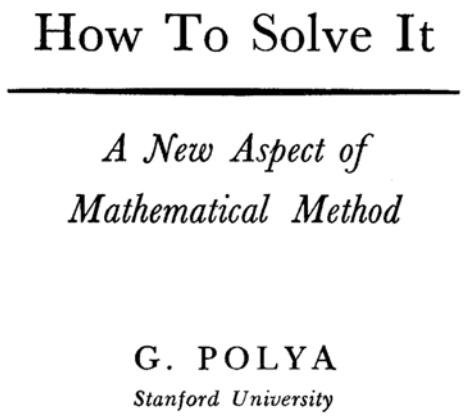
Position

→ Sometimes integration is called "anti-differentiation"

NOTE: Numerically, integration is typically much easier than differentiation

	Derivative Form
Position	$r(t)$
Velocity	$v(t) = \frac{dr}{dt}$
Acceleration	$a(t) = \frac{dv}{dt} = \frac{d^2r}{dt^2}$

Problem Solving



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Wolfson

- Make sure to fully read the problem and understand what is being asked
- Think about it conceptually/intuitively
- Draw a picture. Label things, and include units!
- If stuck, think of it as a puzzle: What pieces do you have (or not)?
- Use scratch paper. Ultimately you want/need to lay out a **CLEAR** solution

Examples

71. ••**Calc** The position versus time function of an object is given by

$$x(t) = 12 - 6t + 3.2t^2 \quad \text{(SI units)}$$

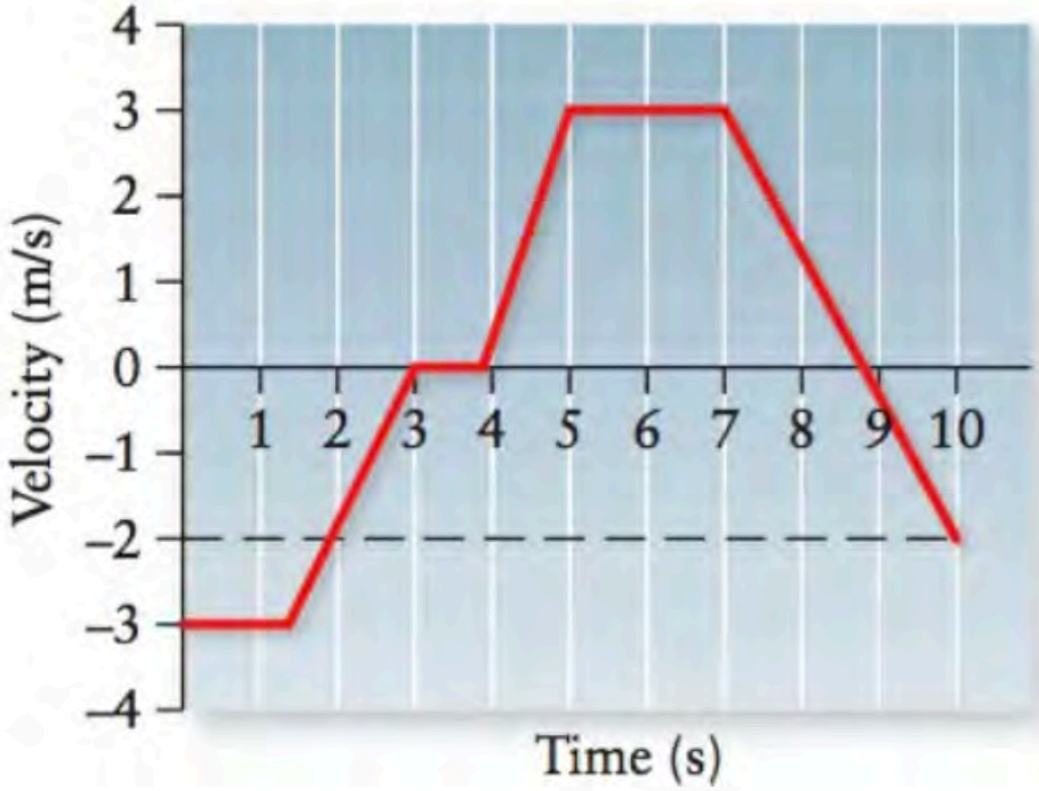
(a) What is the displacement between $t = 4$ s and $t = 8$ s? (b) Calculate $v(t)$ of the object and evaluate the equation at $t = 3$ s. (c) At what time(s) is the velocity equal to zero? (d) Calculate $a(t)$. SSM

Examples

73. •A ball is dropped from rest at a height of 25 m above the ground. (a) How fast is the ball moving when it is 10 m above the ground? (b) How much time is required for it to reach the ground level? Ignore the effects of air resistance.

Examples

92. •In the following graph (Figure 2-27) depicting a moving car, find the instantaneous acceleration at times $t = 2$ s, $t = 4.5$ s, $t = 6$ s, and $t = 8$ s.



Examples

93. ••A ball is dropped from an upper floor, some unknown distance above your apartment. As you look out of your window, which is 1.50 m tall, you observe that it takes the ball 0.18 s to traverse the length of the window. Determine how high above the top of your window the ball was dropped. Ignore the effects of air resistance. SSM