Analyzing Cool Physics Videos

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Go to: Pivotinteractives.com

pivot interactives

And Join a Class with code: 703ee70e

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Outline

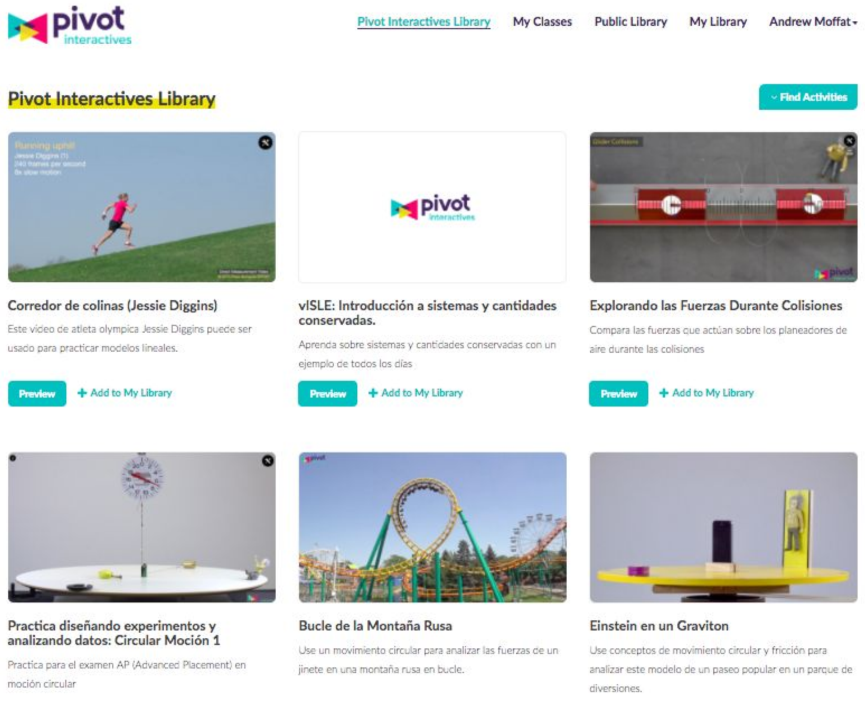
1. Why is Video Analysis Awesome?
2. Why is Pivot Interactives Different?
3. How it Works & Example
   a. SPH3U - Keeping Time! Measuring the Speed of Sound
   b. SPH4UI - Rotational Collisions: Disk on Disk
4. Try it out - 2 options:
   a. SPH3U - Force and Motion during a Hockey Slapshot
   b. SPH4U - Ballistics Simple Pendulum Challenge

Why is Video Analysis Awesome?

1. Allows students to look at real life situations not possible in the classroom
2. Requires students to “Think” to solve them:
    a. Tools
    b. Concepts
3. Time effective
4. Shouldn’t replace labs/activities/demos in class

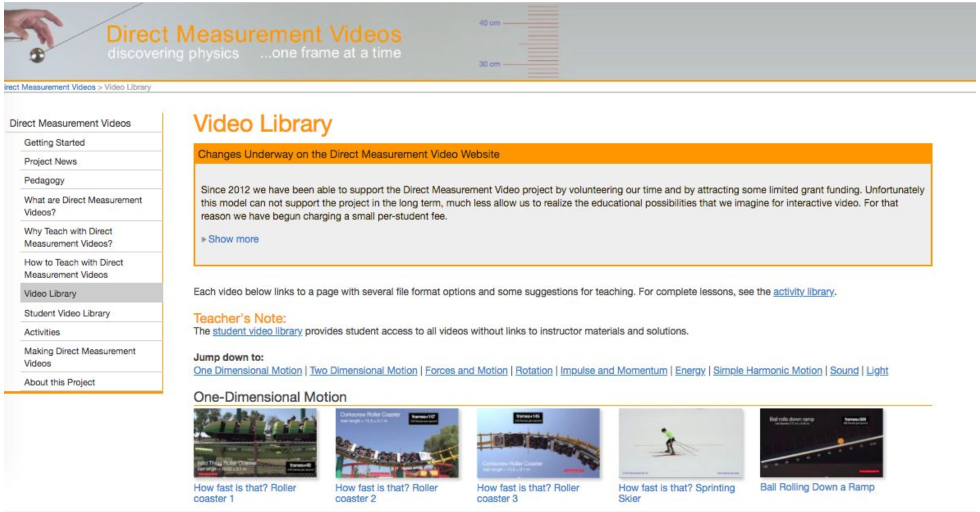
Why is Pivot Different?

1. Flexible, floating tools
2. Searchable videos
3. Easy to use timing features
4. Various frame rates
5. Over 200 High-quality videos (and more all the time)
6. BUT … it costs money :-(



Free (older) Version: Direct Motion Video Library

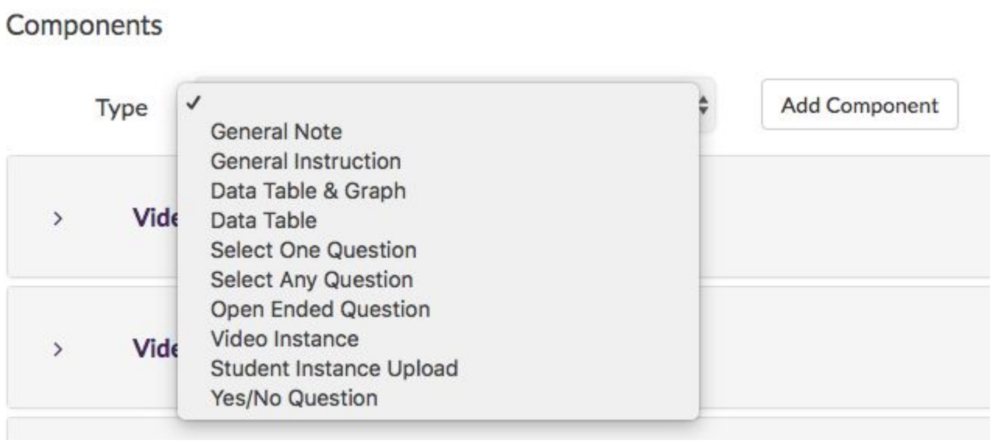
https://serc.carleton.edu/dmvideos/videos.html



Or: Take your own and use video analysis software such as LoggerPro

How Pivot Works and Example

1. Browse the “Pivot Interactives Library”
2. “Add to My Library”
3. Modify as necessary, by adding/editing components:
4. Other options:
    a. Make your own activity
    b. Just use the videos
5. Manage/Assess Classes



SPH3U Example:
Keeping Time! Measuring the Speed of Sound

SPH3U - Keep in Time! Measuring the Speed of Sound

Students use observe the progression of sound waves, watching marching band musicians clapping to the sound of a metronome.

Solution:
Keeping Time! Measuring the Speed of Sound

SPH3U - Keep in Time! Measuring the Speed of Sound

Students use observe the progression of sound waves, watching marching band musicians clapping to the sound of a metronome.

☑	Distance	Time
	m	s
☑ 1	10	0.0333
☑ 2	20	0.0625
☑ 3	30	0.08333
☑ 4	40	0.1
☑ 5	50	0.1167
☑ 6	60	0.1708
☑ 7	70	0.225
☑ 8	80	0.2375
☑ 9		

Horizontal Axis

Time ±

Vertical Axis 1

Distance ±

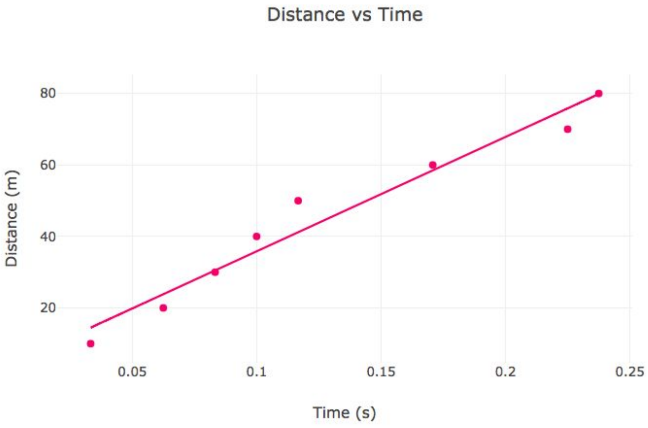
Vertical Axis 2

±

☑ Linear Regression

Distance = 320 · Time + 3.84

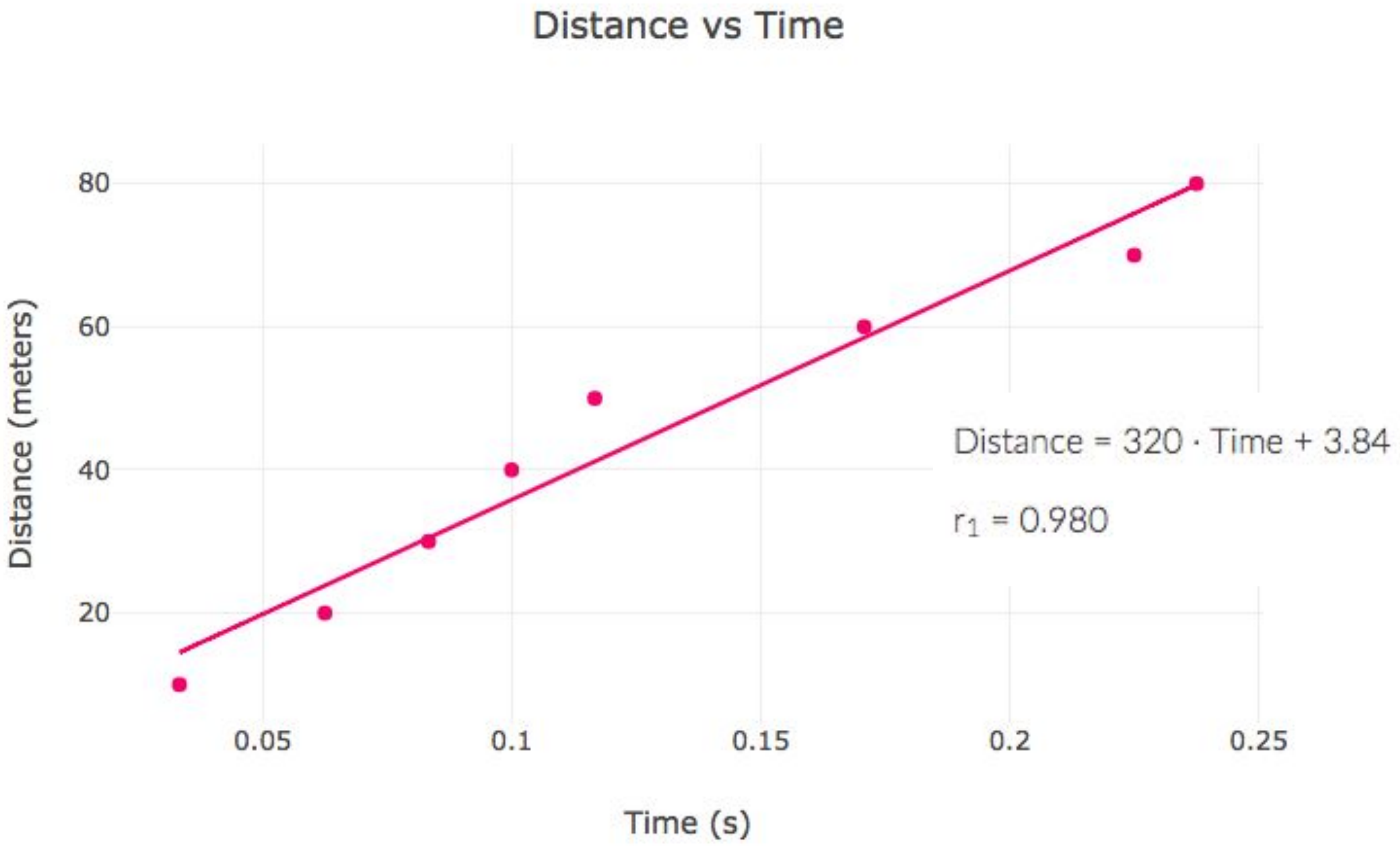
r_1 = 0.980



☑ **Linear Regression**

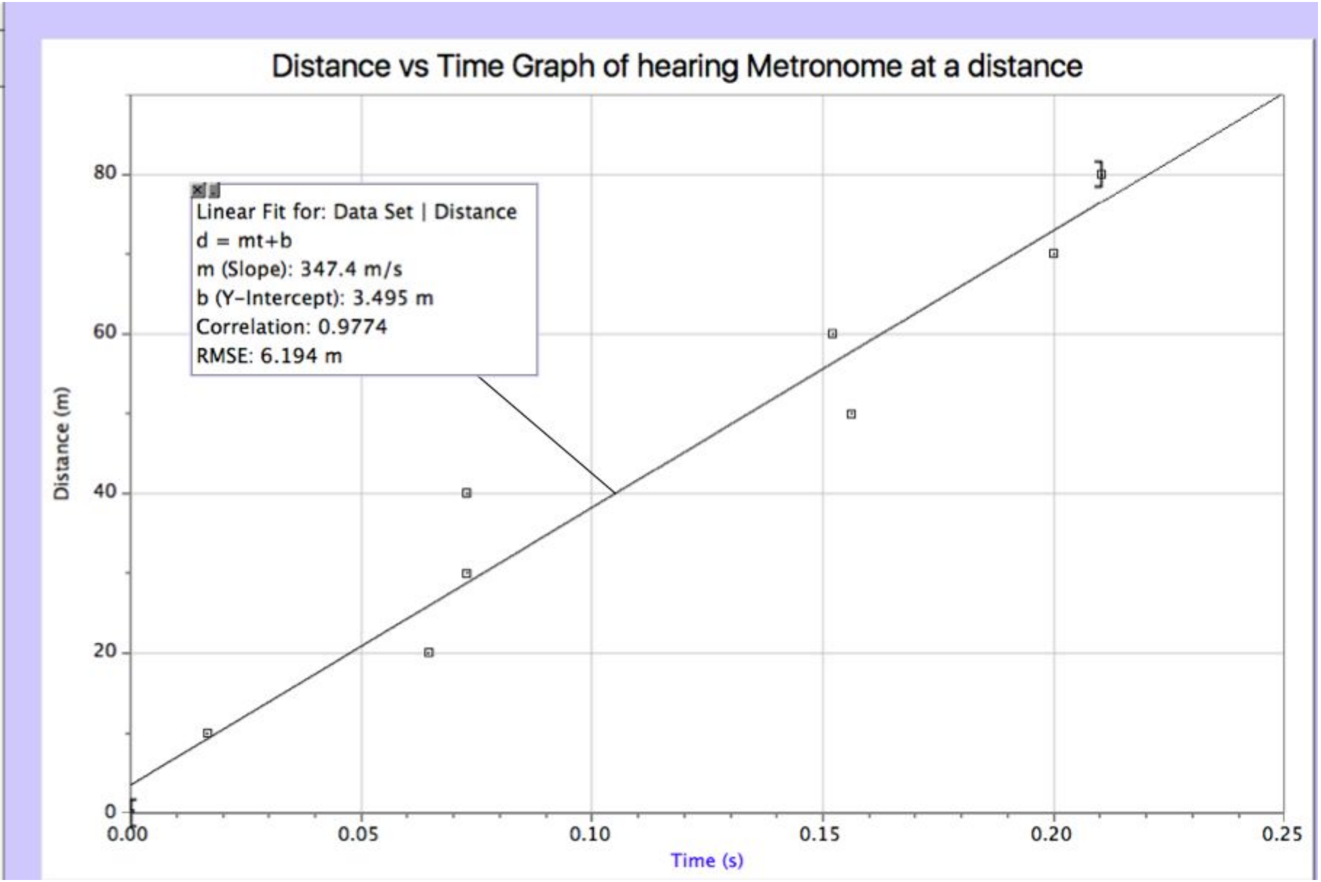
Distance = 320 · Time + 3.84

r_1 = 0.980


Distance vs Time
80
60
40
20
Distance (meters)
0.05
0.1
0.15
0.2
0.25
Time (s)
Distance = 320 · Time + 3.84
r1 = 0.980

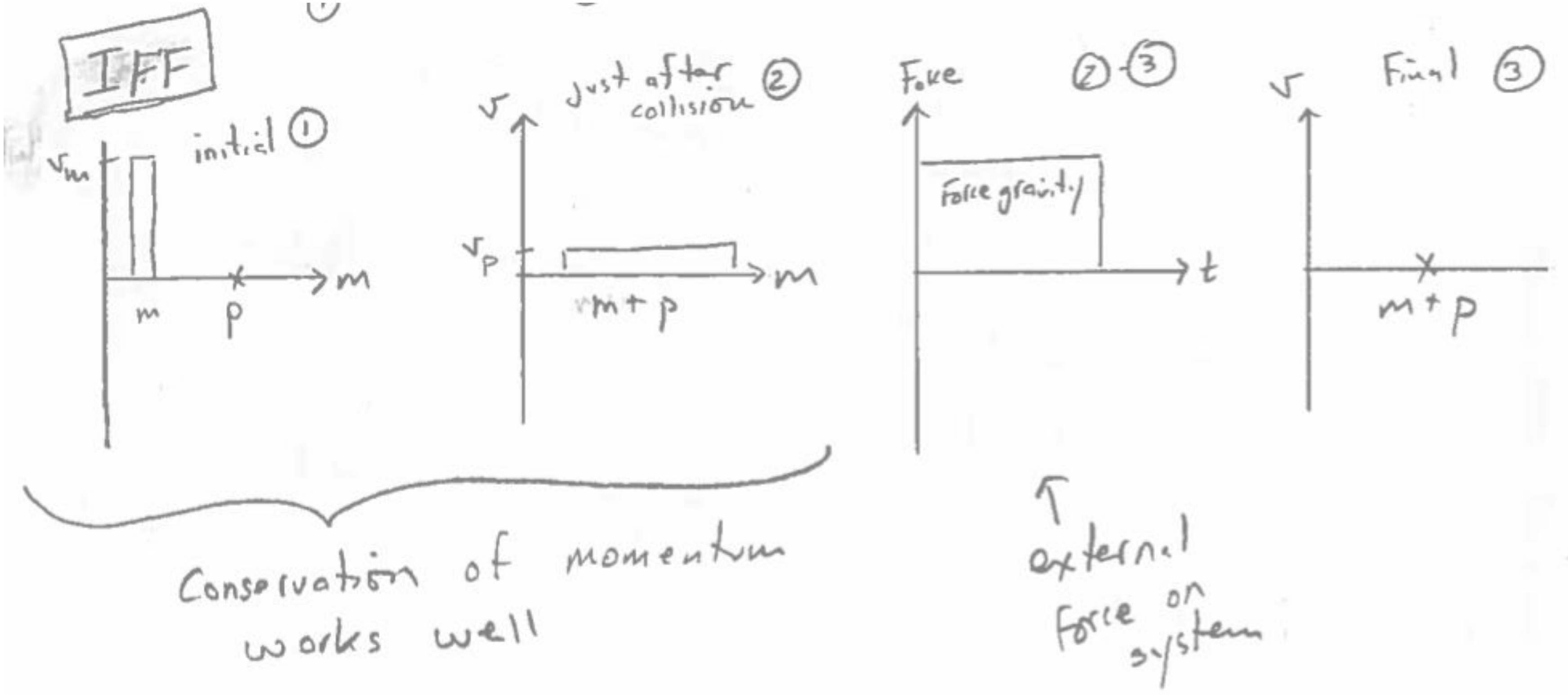
Analysis in LoggerPro

Data Set		
d (m)	Frame (na)	Time (s)
0	68	0.000
10	76	0.017
20	99	0.065
30	103	0.073
40	103	0.073
50	143	0.156
60	141	0.152
70	164	0.200
80	169	0.210



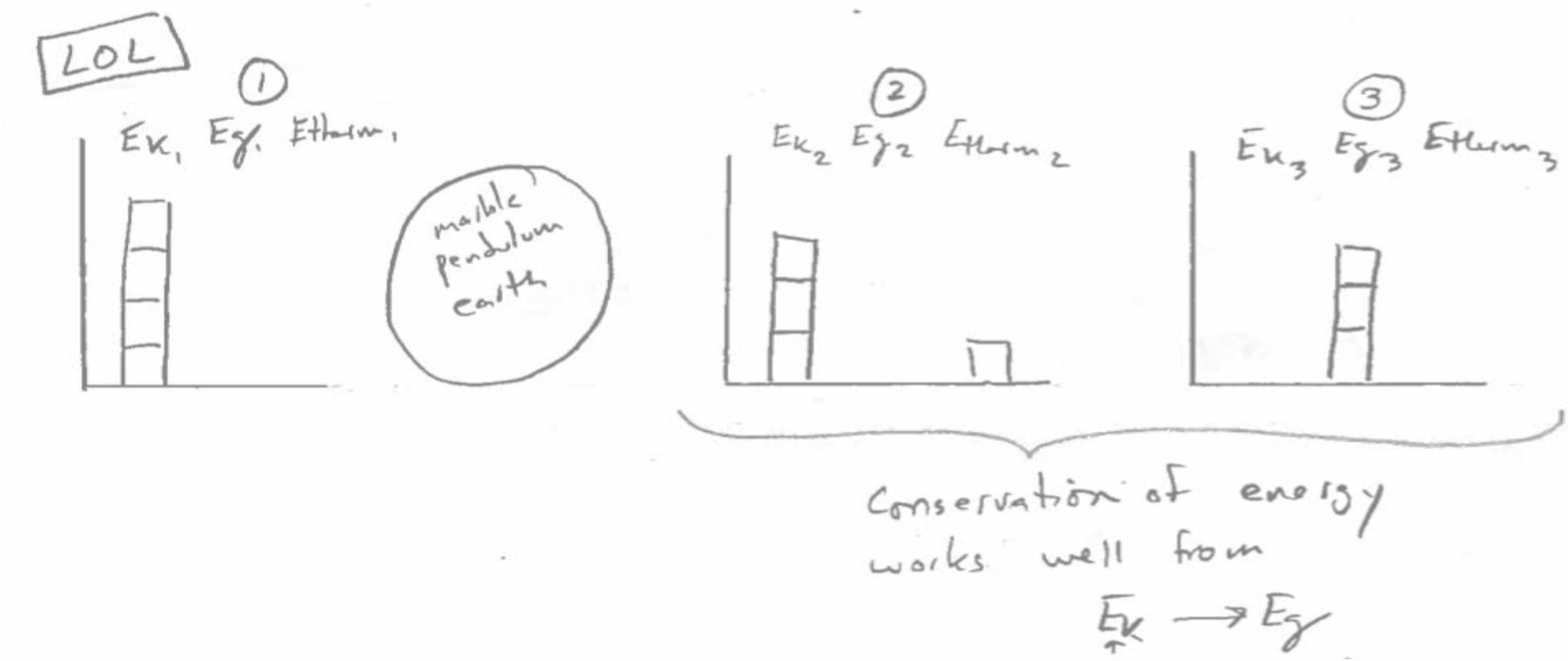
Note on IFF & LOL Diagrams

IFF is diagram to show the transfer of momentum:

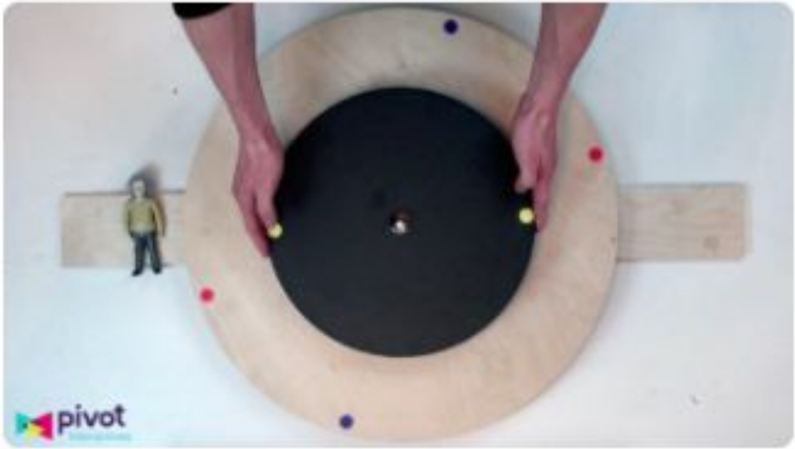


Note on IFF & LOL Diagrams

LOL is a diagram to show the conservation of energy:



SPH4UI Example:
Rotational Collisions: Disk on Disk



SPH4UI - Rotational Collisions: Disk on Disk

A non-rotating disk is dropped onto a rotating one, resulting in a rotational collision.

Solution:
Rotational Collisions: Disk on Disk

SPH4UI - Rotational Collisions: Disk on Disk

A non-rotating disk is dropped onto a rotating one, resulting in a rotational collision.

1. Disk mass: ~3.1 kg
2. % loss in angular momentum: ~5%
3. % loss of kinetic energy: ~57%

#1 Conservation of rotational momentum (using trial #1 - slow motion)

$$L_i = L_f$$

$$I\omega_{\text{initially}} = I\omega_{\text{finally}}$$

$\omega_{\text{large disk initially}} = ?$

$\frac{\pi}{2}$ rotations in 61 frames (0.254167s)

$R_L = 30cm$

$$\therefore \omega_i = \frac{\text{radians}}{\text{second}} = \frac{\pi/2 \text{ rad}}{0.254167 s}$$

$$= 6.18 \text{ rad/s}$$

$\omega_{\text{large+small disk finally}} = ?$

$\frac{\pi}{2}$ rotations in 90 frames (0.375s)

$R_L = 30cm$

$R_s = 18cm$

$$\therefore \omega_f = \frac{\frac{\pi}{2} \text{ rad}}{\text{seconds}} = \frac{\frac{\pi}{2} \text{ rad}}{0.375 s}$$

$$= 4.19 \text{ rad/s}$$

$$L_i = L_f \qquad I_{Disk} = \frac{1}{2} MR^2$$

$$I_i \omega_i = I_f \omega_f$$

$$\frac{1}{2} M_L R^2 \cdot \omega_i = \left(\frac{1}{2} M_L R_L^2 + \frac{1}{2} M_s R_s^2\right) \omega_f$$

$$M_s = \frac{\frac{M_L R^2 \omega_i}{\omega_f} - M_L R^2}{R_s^2} = \frac{\frac{2.85 kg \cdot (0.3 m)^2 \cdot 6.18 rad/s}{4.19 rad/s} - 2.85 kg \cdot (0.3 m)^2}{(.18 m)^2}$$

$$= 3.76 kg$$

∴ The mass of the small disk is approximately 3.8 kg

SPH3U Example:
Force and Motion During a Hockey Slapshot

SPH3U - Force and Motion During a Hockey Slapshot

Explore the force applied to a hockey puck during a slap shot.

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Explore the force applied to a hockey puck during a slap shot.

Solution:
Force and Motion During a Hockey Slapshot

1. Average Force ~ 135-140 N

$$\vec{F}_{av} = m\vec{a} \Rightarrow \quad \vec{a} = \frac{\Delta v}{\Delta t} = \frac{V_{max} - 0}{\Delta t}$$

$$V_{max} = \frac{\Delta d}{\Delta t} = \frac{1.45\,m}{0.0458\,s} \leftarrow 11 \text{ frames}$$

$$= 31.66\,m/s$$

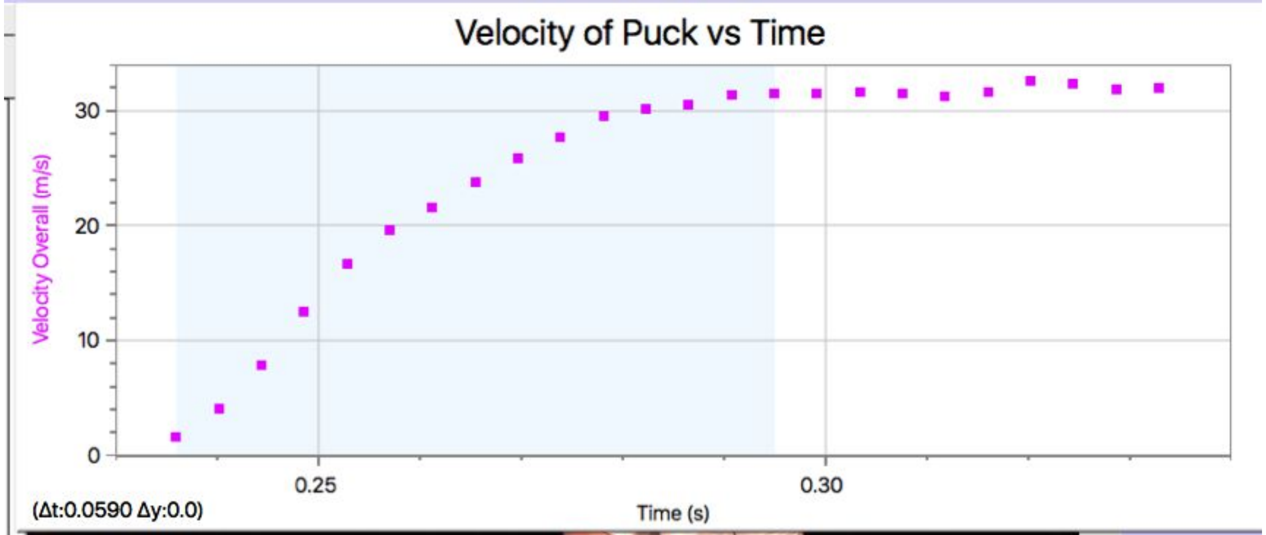
Time of shot (puck & stick in contact) = 9 frames (0.0375 s)

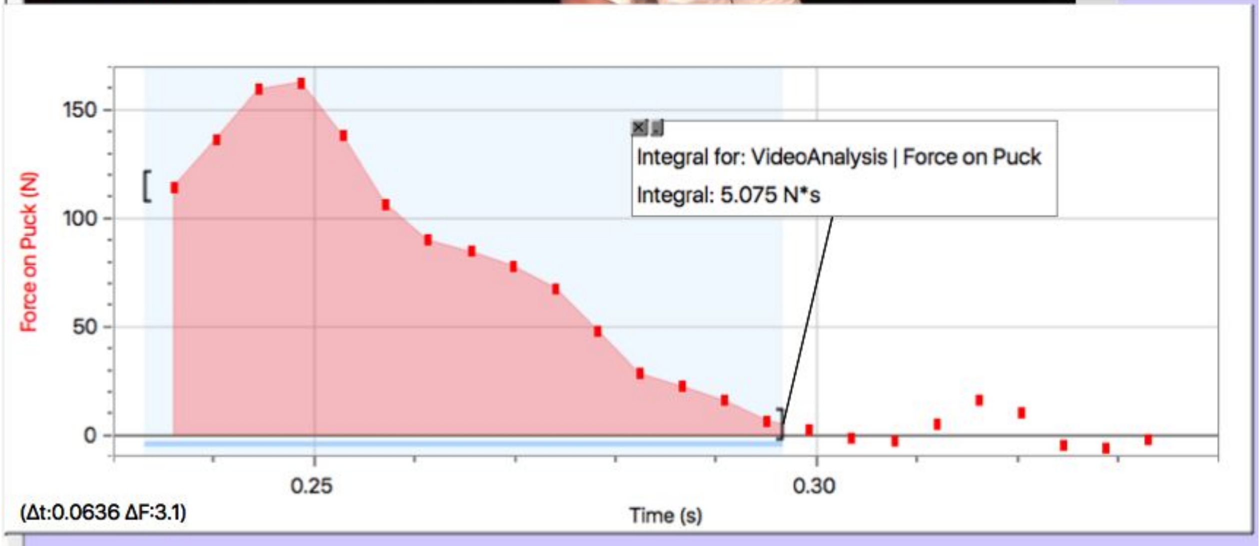
$$\therefore \vec{F}_{av} = 0.1697\,kg \cdot \frac{31.66\,m/s}{0.0375\,s}$$

$$= 143.3\,N \ [fwd]$$

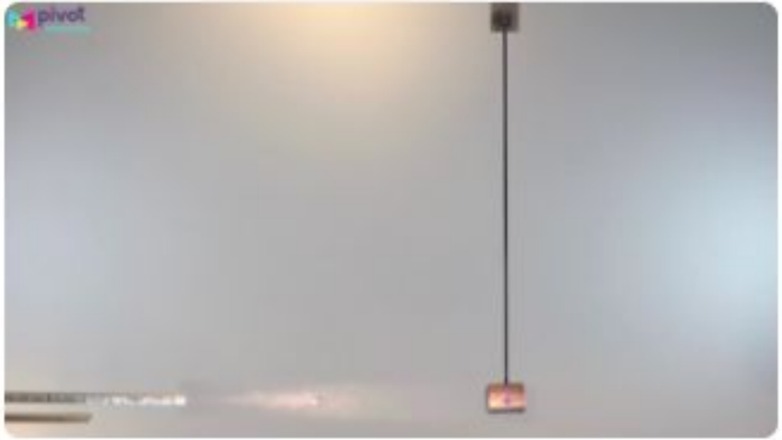
$\therefore$ Average force of shot was ~140 N

Analysis in LoggerPro





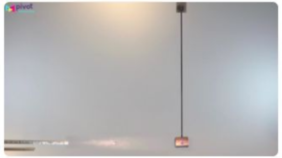
SPH4U Example:
Ballistic Simple Pendulum Challenge



SPH4U - Ballistic Simple Pendulum Challenge

A challenging physics classic with an interesting real-world twist

Solution:
Ballistic Simple Pendulum Challenge

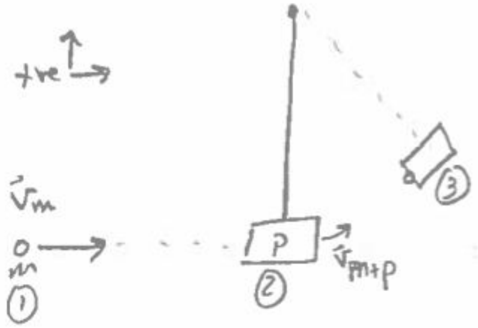


SPH4U - Ballistic Simple Pendulum Challenge

A challenging physics classic with an interesting real-world twist

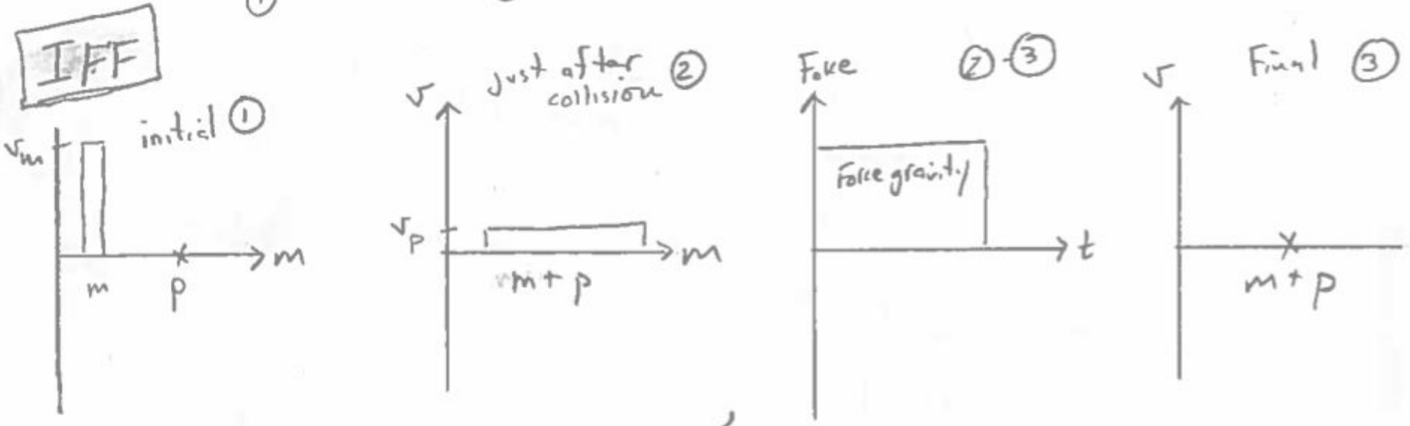
1. Speed of Pendulum: ~1.6 m/s
2. Speed of Marble: ~96 m/s

Part 1:



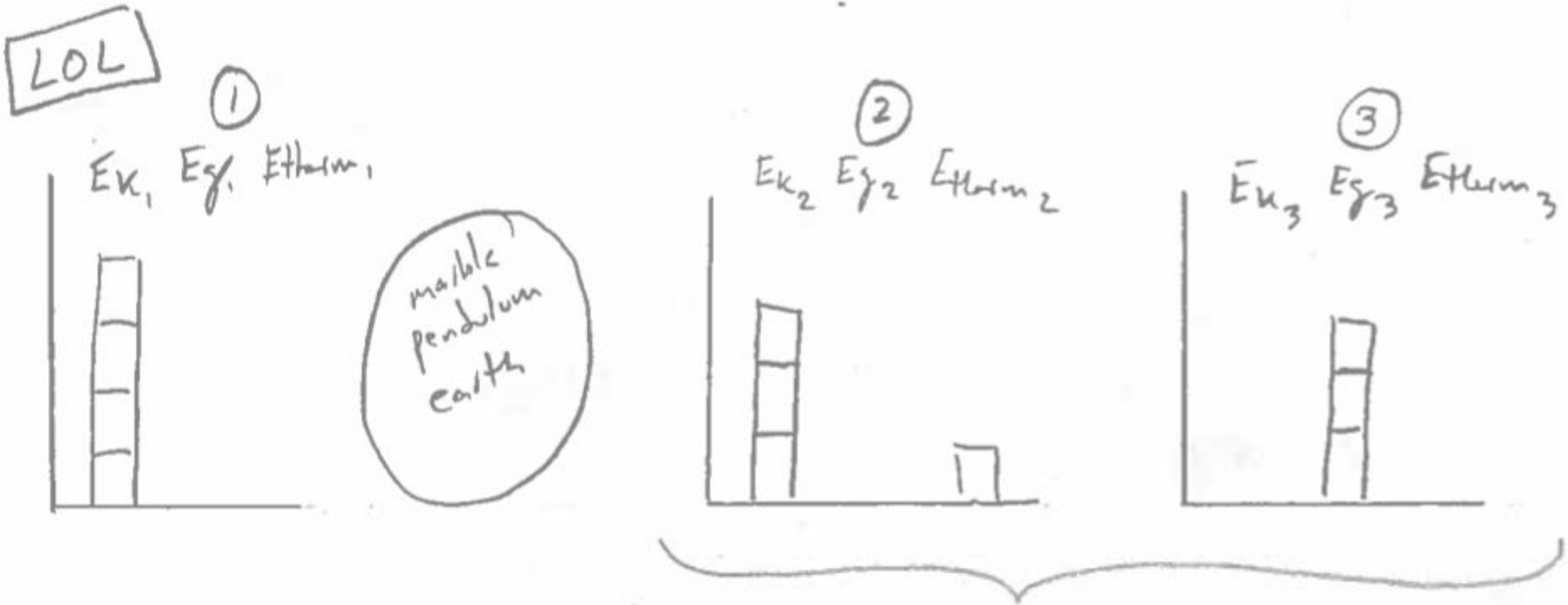
m = marble

p = pendulum



Conservation of momentum works well

external force on system



Conservation of energy works well from

$E_k \rightarrow E_g$

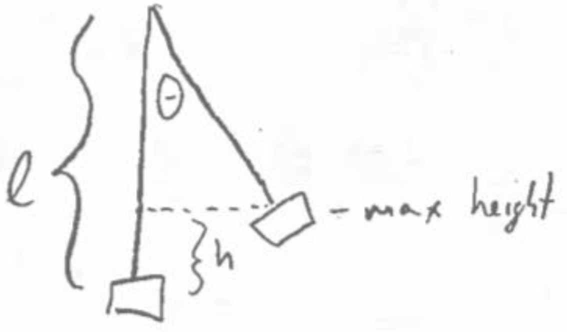
m+p after collision → m+p @ max height

1. $E_{K_2} = E_{g_3}$

$$\frac{1}{2} m_{m+p} \vec{v}_{m+p}^{\,2} = m_{m+p}\, g h$$

$$\vec{v}_{m+p} = \sqrt{2gh}$$

From video



$\Theta = 35°$

$$h = l - l\cos\Theta$$
$$= .76m - .76\cos 35°$$
$$= 0.137\ m$$

$$\vec{v}_{m+p} = \sqrt{2 \cdot 9.81\ m/s^2 \cdot 0.137\ m}$$
$$= 1.64\ m/s$$

∴ The velocity of marble/pendulum after collision was ~1.64 m/s

2. $p_1 = p_2$

$$m_m \vec{v}_m = m_{m+p} \vec{v}_{m+p}$$

$$\vec{v}_m = \frac{m_{m+p} \vec{v}_{m+p}}{m_m} = \frac{(.01\,kg + 0.578\,kg)(1.64\,m/s)}{.01\,kg}$$

$$= 96.4\ m/s$$

∴ The velocity of the marble (shot velocity) was about 96 m/s as measured using ballistics pendulum.

3. Did not include mass of arm, air resistance, uncertainty, energy lost to sound or friction, bending of rod or air from air gun.