

Analyzing Cool Physics Videos

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Go to: Pivotinteractives.com



And

Join a Class

with code: 703ee70e

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Outline

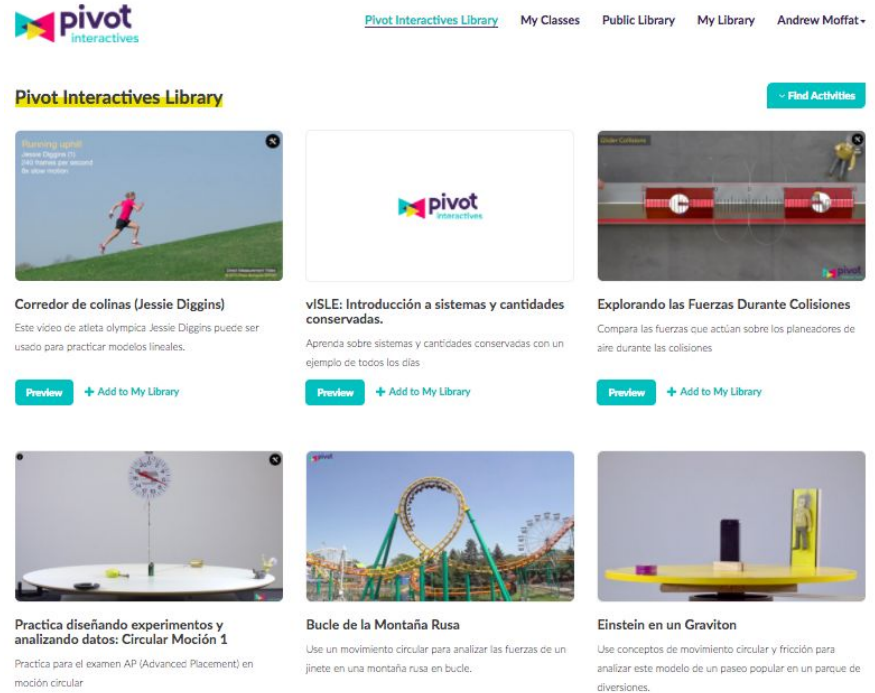
1. Why is Video Analysis Awesome?
2. Why is Pivot Interactives Different?
3. How it Works & Example
 - a. SPH3U - Keeping Time! Measuring the Speed of Sound
 - b. SPH4UI - Rotational Collisions: Disk on Disk
4. Try it out - 2 options:
 - a. SPH3U - Force and Motion during a Hockey Slapshot
 - b. SPH4U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



The screenshot shows the Pivot Interactives Library website. At the top, there is a navigation bar with the Pivot logo, "Pivot Interactives Library", "My Classes", "Public Library", "My Library", and "Andrew Moffat". Below the navigation bar, the page is titled "Pivot Interactives Library" and features a "Find Activities" button. The main content area displays a grid of video thumbnails, each with a title, a brief description, and a "Preview" button with a plus sign to "Add to My Library".

Corredor de colinas (Jessie Diggins)
Este vídeo de atleta olímpica Jessie Diggins puede ser usado para practicar modelos lineales.

viSLE: Introducción a sistemas y cantidades conservadas.
Aprenda sobre sistemas y cantidades conservadas con un ejemplo de todos los días.

Explorando las Fuerzas Durante Colisiones
Compara las fuerzas que actúan sobre los planeadores de aire durante las colisiones.

Práctica diseñando experimentos y analizando datos: Circular Movimiento 1
Práctica para el examen AP (Advanced Placement) en movimiento circular.

Bucle de la Montaña Rusa
Use un movimiento circular para analizar las fuerzas de un jinete en una montaña rusa en bucle.

Einstein en un Graviton
Use conceptos de movimiento circular y fricción para analizar este modelo de un paseo popular en un parque de diversiones.

Free (older) Version: Direct Motion Video Library

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

The screenshot shows the website's header with the title "Direct Measurement Videos" and the tagline "discovering physics ...one frame at a time". A navigation menu on the left lists various sections, with "Video Library" selected. The main content area features a "Video Library" heading and a prominent orange box titled "Changes Underway on the Direct Measurement Video Website". Below this, there is a paragraph explaining the project's funding situation and a "Show more" link. Further down, a "Teacher's Note" section provides information about student access. A "Jump down to:" section lists various physics topics. At the bottom, a "One-Dimensional Motion" section displays five video thumbnails with titles such as "How fast is that? Roller coaster 1", "How fast is that? Roller coaster 2", "How fast is that? Roller coaster 3", "How fast is that? Sprinting Skier", and "Ball Rolling Down a Ramp".

Direct Measurement Videos
discovering physics ...one frame at a time

Direct Measurement Videos > Video Library

Video Library

Changes Underway on the Direct Measurement Video Website

Since 2012 we have been able to support the Direct Measurement Video project by volunteering our time and by attracting some limited grant funding. Unfortunately this model can not support the project in the long term, much less allow us to realize the educational possibilities that we imagine for interactive video. For that reason we have begun charging a small per-student fee.

[Show more](#)

Each video below links to a page with several file format options and some suggestions for teaching. For complete lessons, see the [activity library](#).

Teacher's Note:
The [student video library](#) provides student access to all videos without links to instructor materials and solutions.

Jump down to:
[One Dimensional Motion](#) | [Two Dimensional Motion](#) | [Forces and Motion](#) | [Rotation](#) | [Impulse and Momentum](#) | [Energy](#) | [Simple Harmonic Motion](#) | [Sound](#) | [Light](#)

One-Dimensional Motion

How fast is that? Roller coaster 1

How fast is that? Roller coaster 2

How fast is that? Roller coaster 3

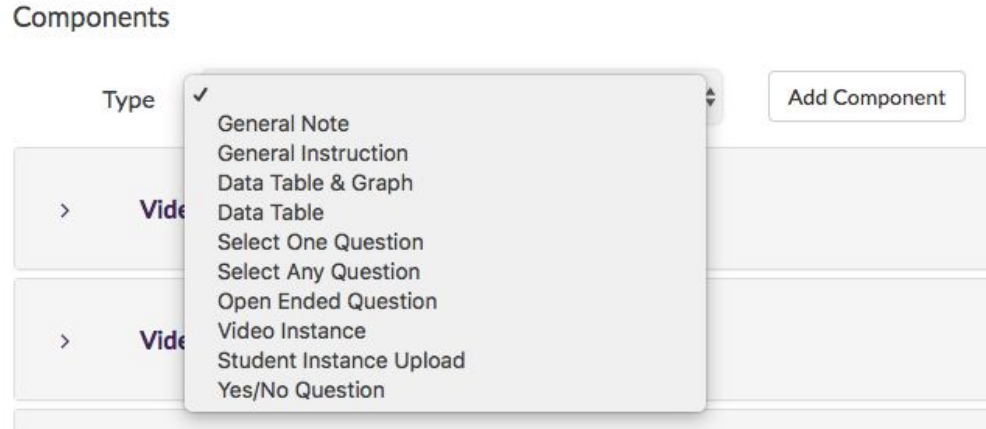
How fast is that? Sprinting Skier

Ball Rolling Down a Ramp

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.

<input checked="" type="checkbox"/>	Distance	:	Time	:
	m		s	
<input checked="" type="checkbox"/>	10		0.0333	
<input checked="" type="checkbox"/>	20		0.0625	
<input checked="" type="checkbox"/>	30		0.08333	
<input checked="" type="checkbox"/>	40		0.1	
<input checked="" type="checkbox"/>	50		0.1167	
<input checked="" type="checkbox"/>	60		0.1708	
<input checked="" type="checkbox"/>	70		0.225	
<input checked="" type="checkbox"/>	80		0.2375	
<input checked="" type="checkbox"/>	9			

Horizontal Axis

Time \pm

Vertical Axis 1

Distance \pm

Vertical Axis 2

\pm

Linear Regression

Distance = 320 · Time + 3.84

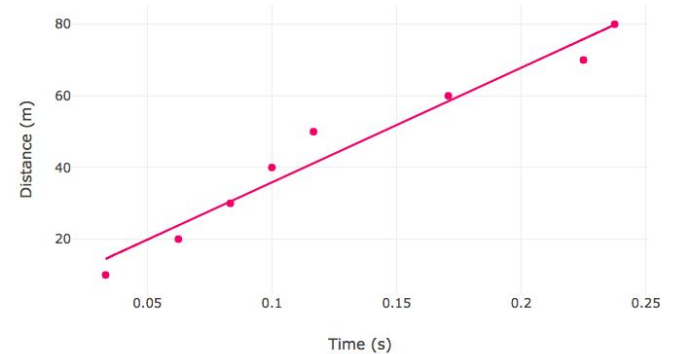
$r_1 = 0.980$

Linear Regression

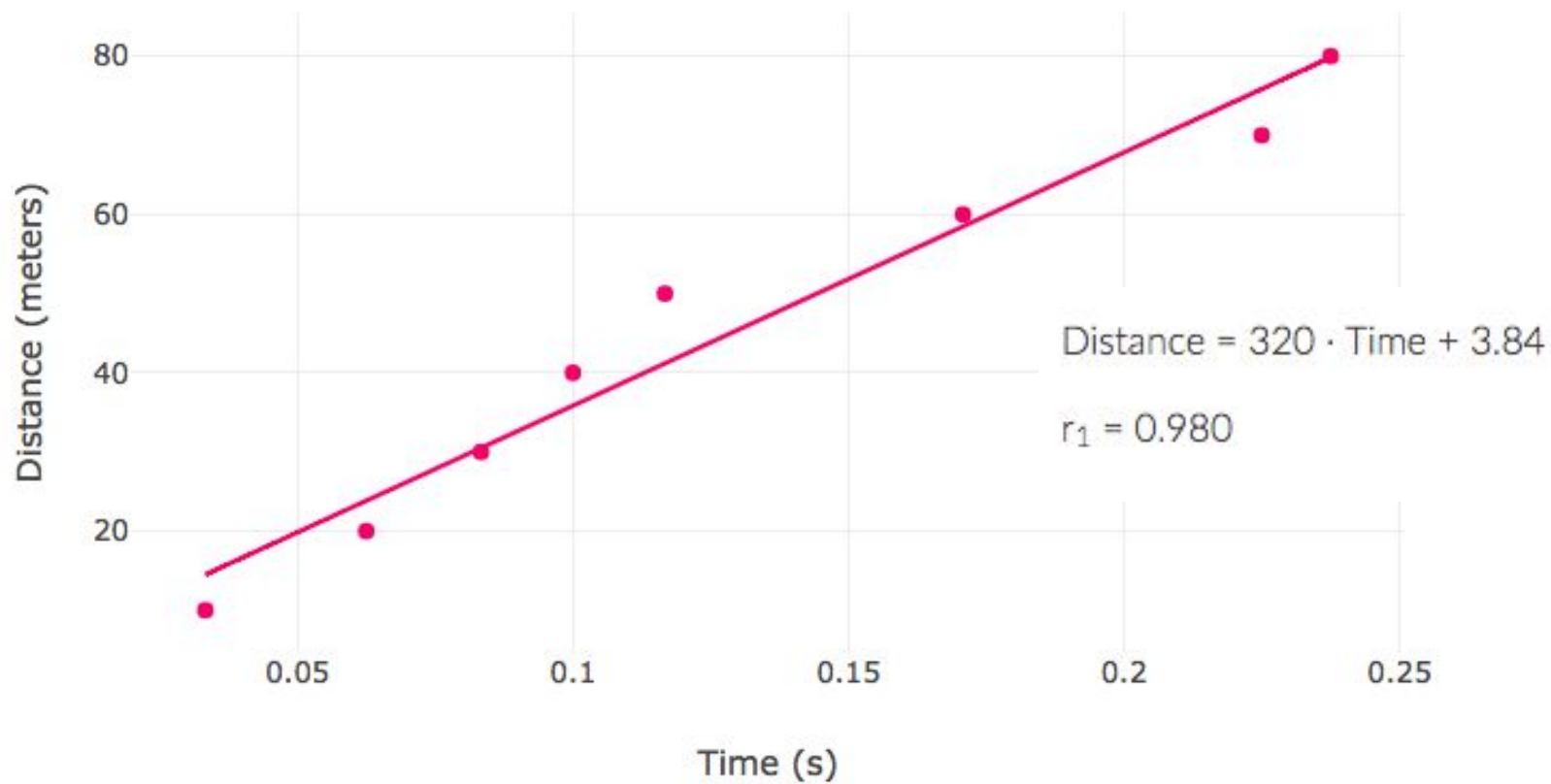
Distance = 320 · Time + 3.84

$r_1 = 0.980$

Distance vs Time

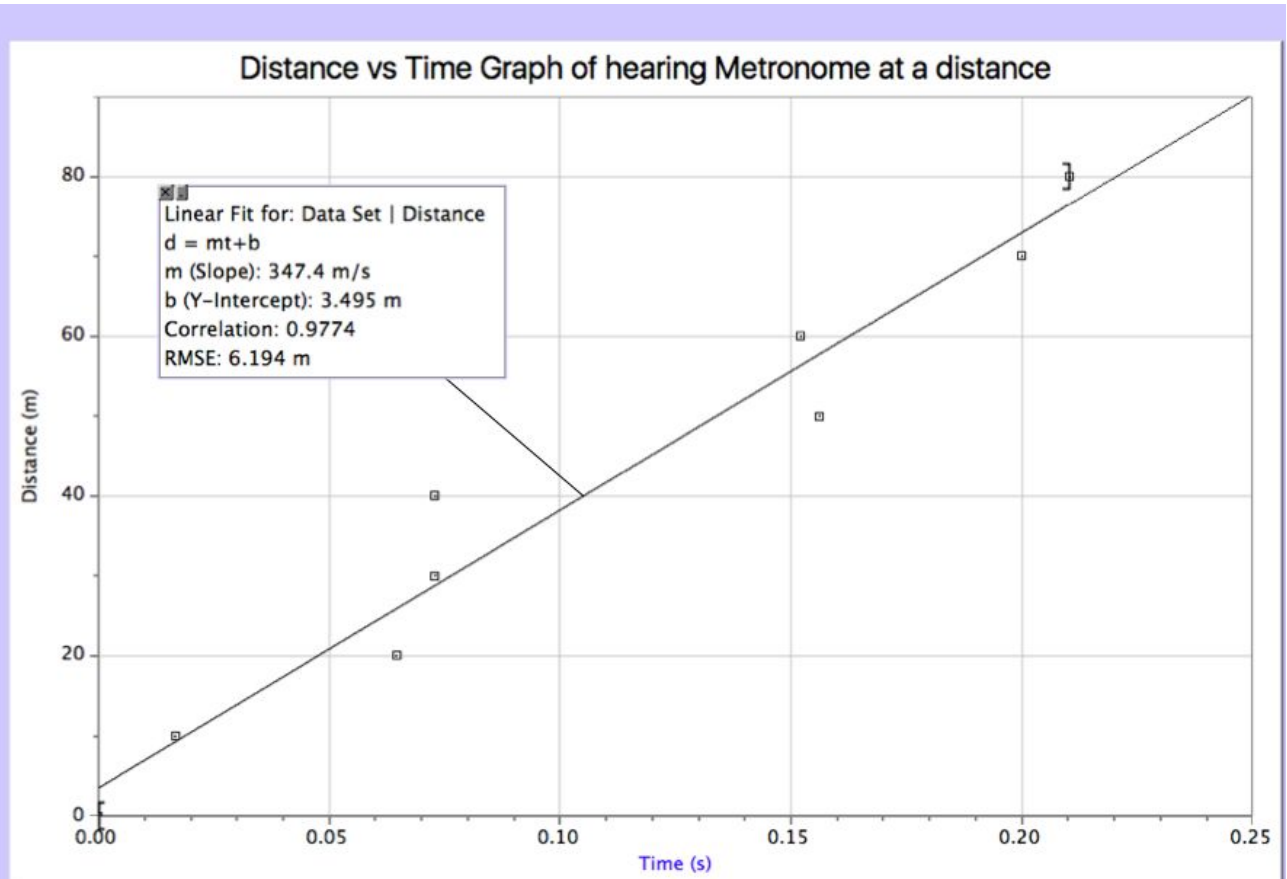


Distance vs Time



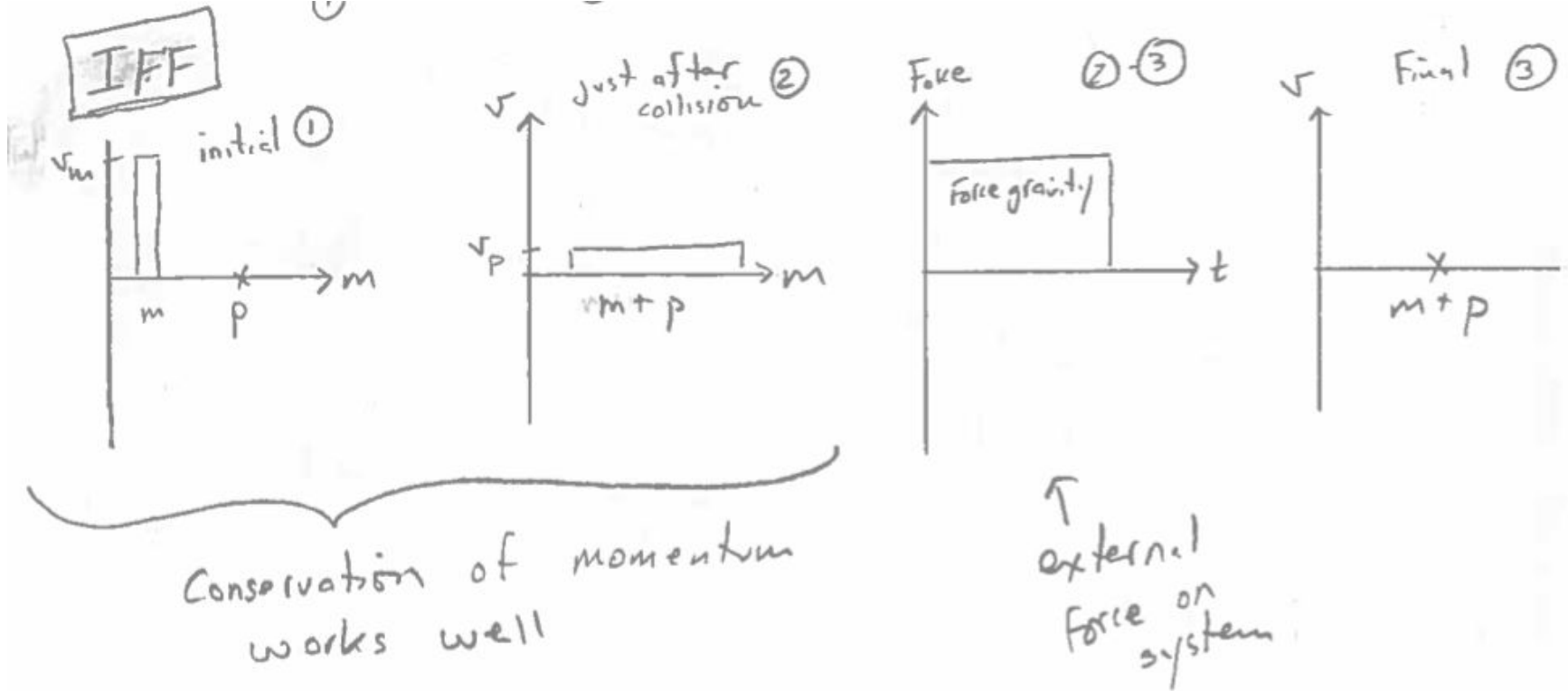
Analysis in LoggerPro

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



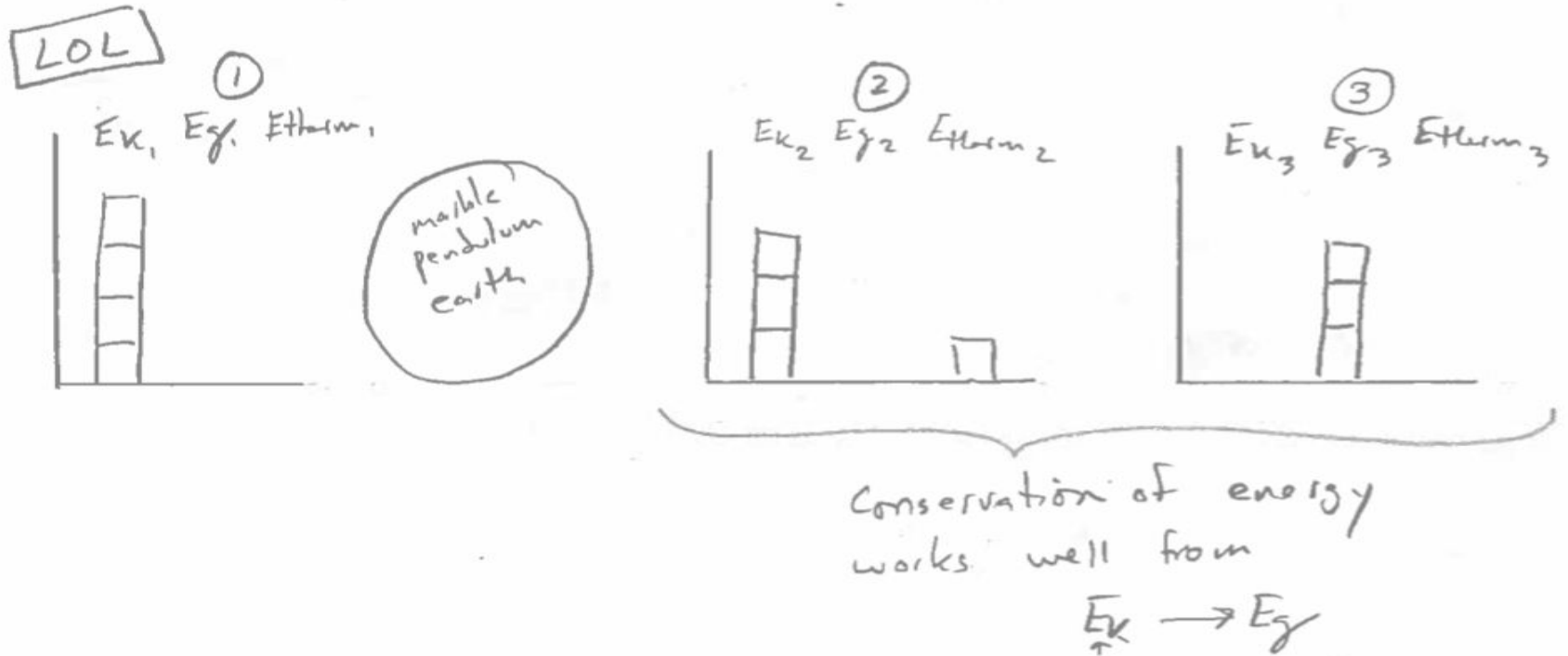
Note on IFF & LOL Diagrams

IFF is diagram to show the transfer of momentum:

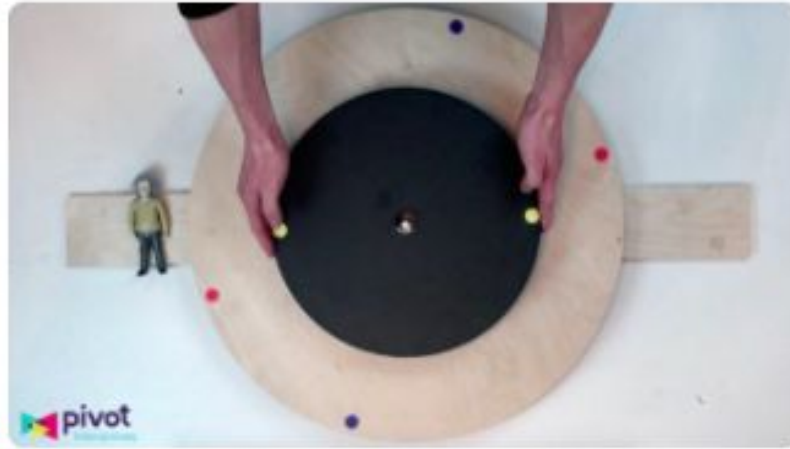


Note on IFF & LOL Diagrams

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

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



SPH4UI - Rotational Collisions: Disk on Disk

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

#1

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

$$L_i = L_f$$

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

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

$$R_L = 30 \text{ cm}$$

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

$$\therefore \omega_i = \frac{\text{rotations}}{\text{seconds}} = \frac{\pi/2 \text{ rad}}{0.254167 \text{ s}}$$

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

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

$$R_L = 30 \text{ cm}$$

$$R_S = 18 \text{ cm}$$

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

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

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

$$L_i = L_f$$

$$I_{\text{disk}} = \frac{1}{2}MR^2$$

$$I_i \omega_i = I_f \omega_f$$

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

$$M_S = \frac{\frac{M_L R^2 \omega_i}{\omega_f} - M_L R^2}{R_S^2} =$$

$$\frac{2.85 \text{ kg} \cdot (0.3 \text{ m})^2 \cdot 6.18 \text{ rad/s} - 2.85 \text{ kg} \cdot (0.3 \text{ m})^2}{4.19 \text{ rad/s} \cdot (0.18 \text{ m})^2}$$

$$= 3.76 \text{ kg}$$

\therefore The mass of the small ^{disk} is approximately 3.8 kg

1 11 (cc7)

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.



SPH3U - Force and Motion During a Hockey Slapshot

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

Solution:

Force and Motion During a Hockey Slapshot

1. Average Force $\sim 135\text{-}140\text{ N}$

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

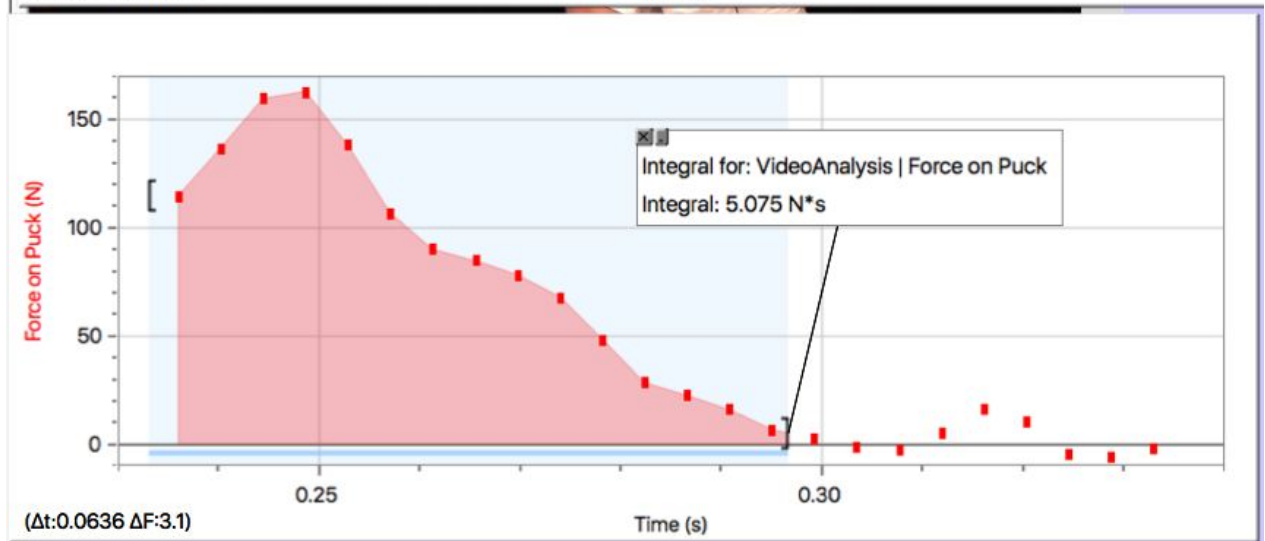
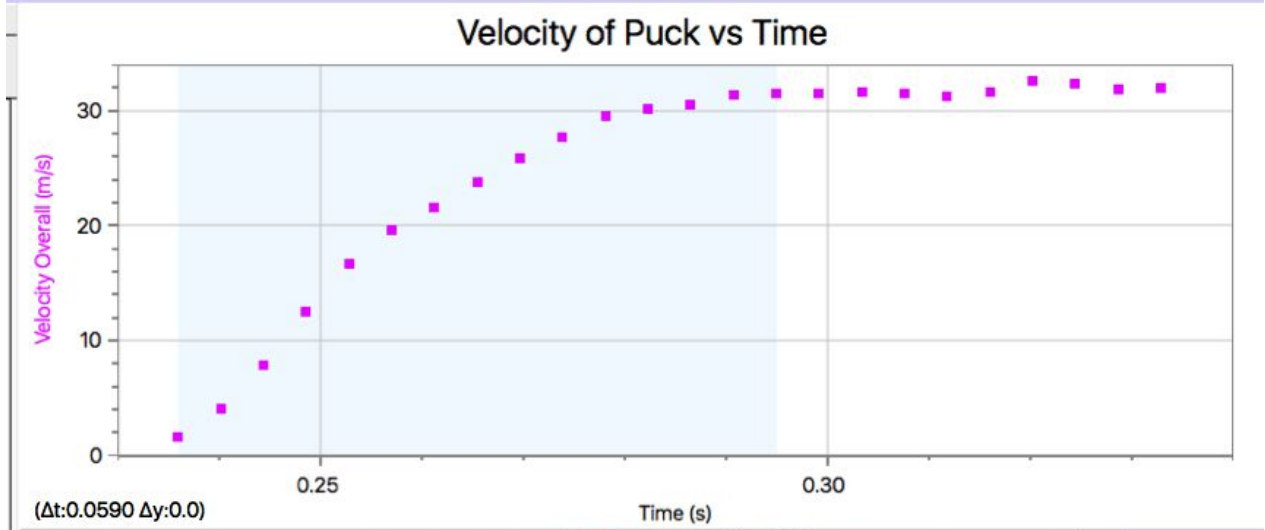
$$v_{max} = \frac{\Delta d}{\Delta t} = \frac{1.45 \text{ m}}{0.0458 \text{ s}} \leftarrow 11 \text{ frames}$$
$$= 31.66 \text{ m/s}$$

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

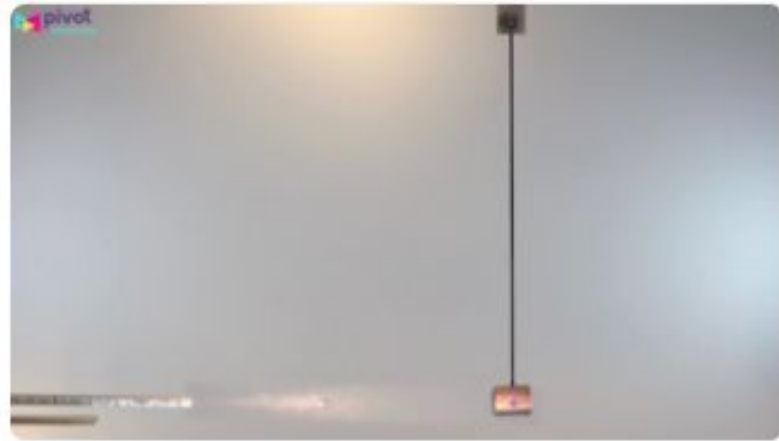
$$\therefore \vec{F}_{av} = 0.1697 \text{ kg} \cdot \frac{31.66 \text{ m/s}}{0.0375 \text{ s}}$$
$$= 143.3 \text{ N} \quad [\text{fwd}]$$

\therefore Average force of shot was $\sim 140 \text{ N}$

Analysis in LoggerPro



SPH4U Example: Ballistic Simple Pendulum Challenge



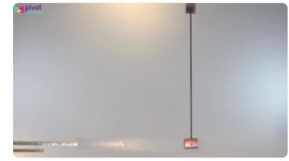
SPH4U - Ballistic Simple Pendulum Challenge

A challenging physics classic with an interesting real-world twist

Solution:

Ballistic Simple Pendulum Challenge

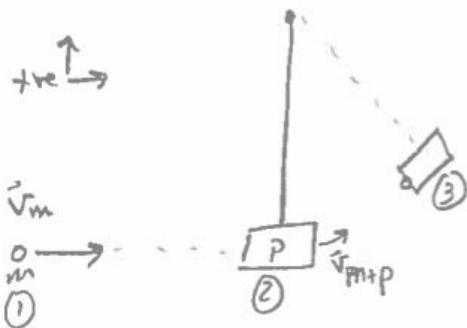
1. Speed of Pendulum: ~ 1.6 m/s
2. Speed of Marble: ~ 96 m/s



SPH4U - Ballistic Simple Pendulum Challenge

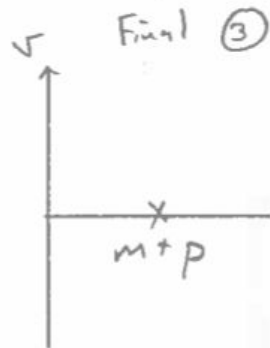
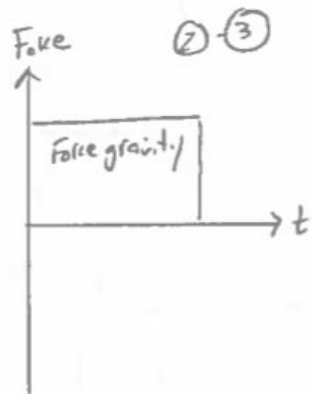
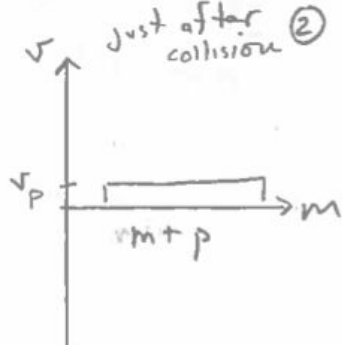
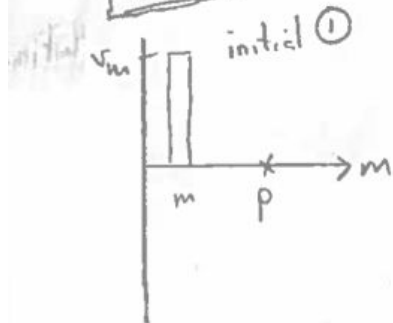
A challenging physics classic with an interesting real-world twist

Part 1:



$m = \text{marble}$
 $p = \text{pendulum}$

IFF

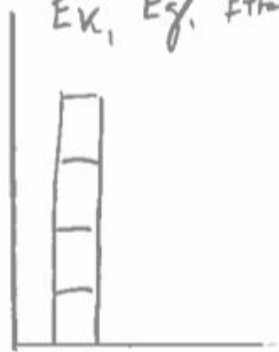


Conservation of momentum works well

↑ external force on system

LOL

①
 E_{K1}, E_{P1}, E_{th1}

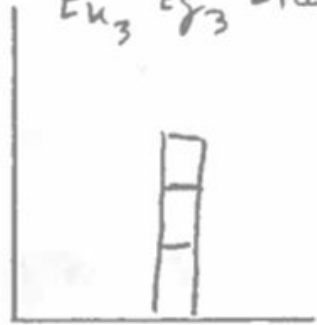


marble
pendulum
carts

②
 E_{K2}, E_{P2}, E_{th2}



③
 E_{K3}, E_{P3}, E_{th3}



Conservation of energy
works well from

$$\begin{matrix} E_K & \rightarrow & E_P \\ \uparrow & & \uparrow \\ m+P & & m+P \\ \text{after collision} & & @ \text{max height} \end{matrix}$$

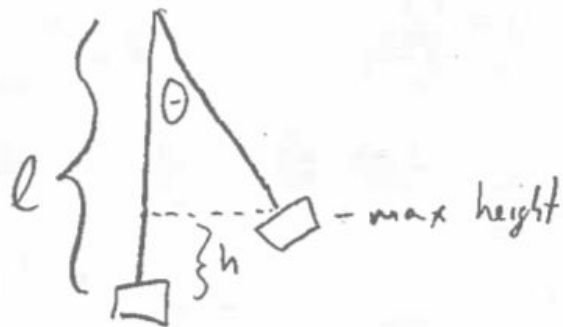
1.

$$E_{k2} = E_{g3}$$

$$\frac{1}{2} m_{mp} \vec{v}_{mp}^2 = m_{mp} g h$$

$$\vec{v}_{mp} = \sqrt{2gh}$$

From video



$$\theta = 35^\circ$$

$$h = l - l \cos \theta$$

$$= .76 \text{ m} - .76 \cos 35^\circ$$

$$= 0.137 \text{ m}$$

$$\vec{v}_{mp} = \sqrt{2 \cdot 9.81 \text{ m/s}^2 \cdot 0.137 \text{ m}}$$

$$= 1.64 \text{ m/s}$$

\therefore The velocity of marble/pendulum after collision was $\sim 1.64 \text{ m/s}$

2. $P_1 = P_2$

$$M_m \vec{v}_m = M_{m+p} \vec{v}_{m+p}$$

$$\vec{v}_m = \frac{M_{m+p} \vec{v}_{m+p}}{M_m} = \frac{(.01 \text{ kg} + 0.578 \text{ kg})(1.64 \text{ m/s})}{.01 \text{ kg}}$$
$$= 96.4 \text{ m/s}$$

\therefore 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/friction, bending of rod or air from air gun.