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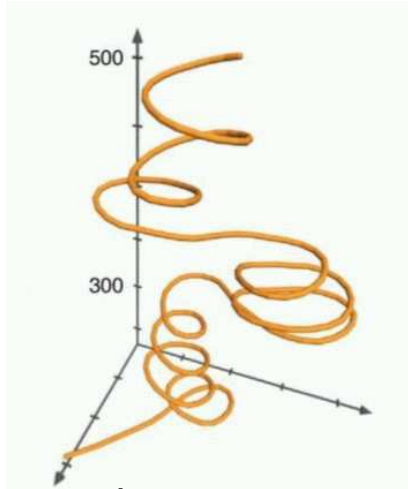

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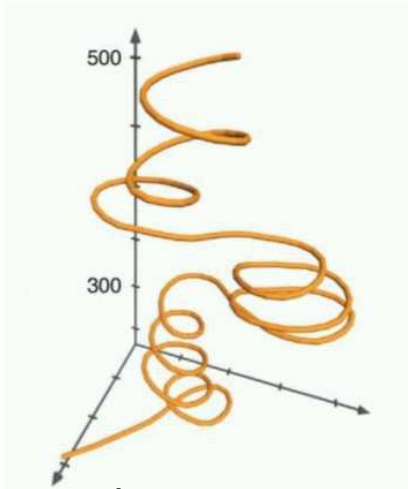

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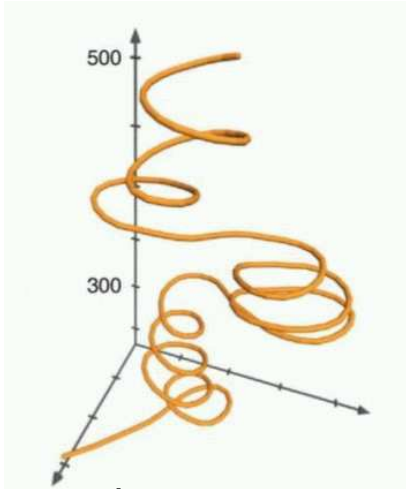

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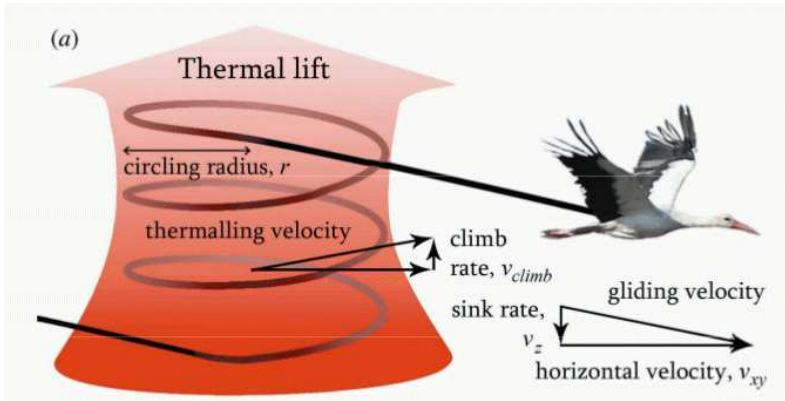

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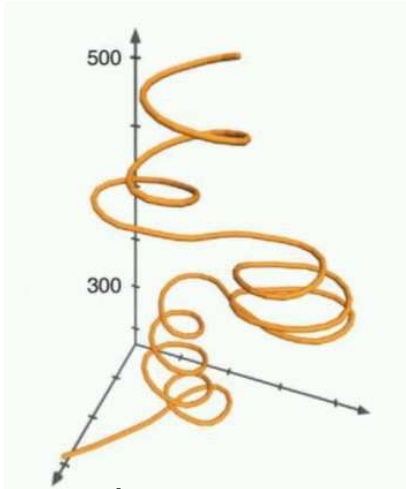

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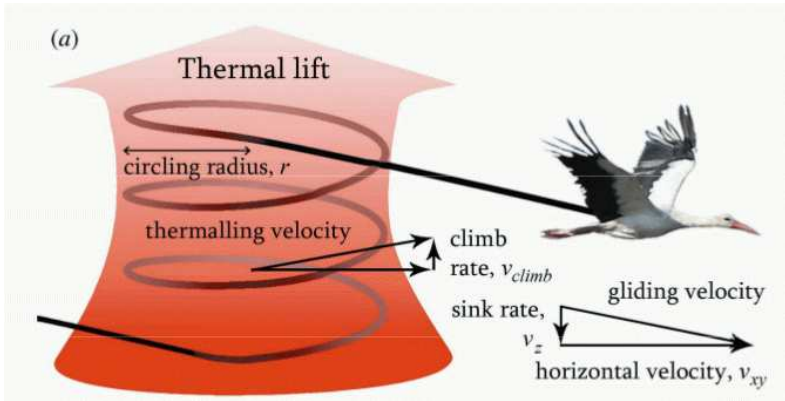

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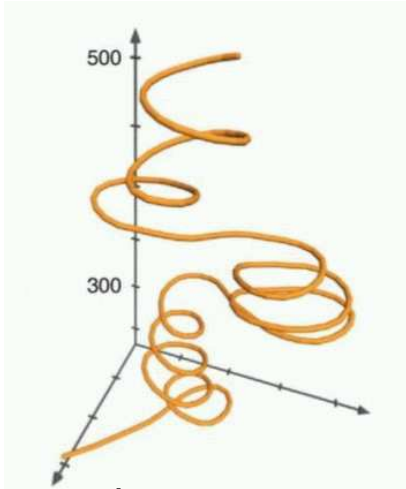

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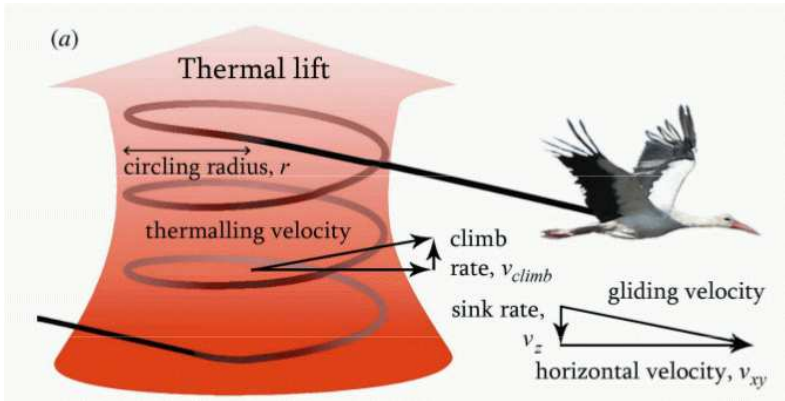

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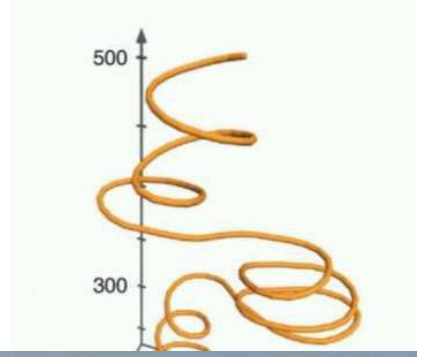

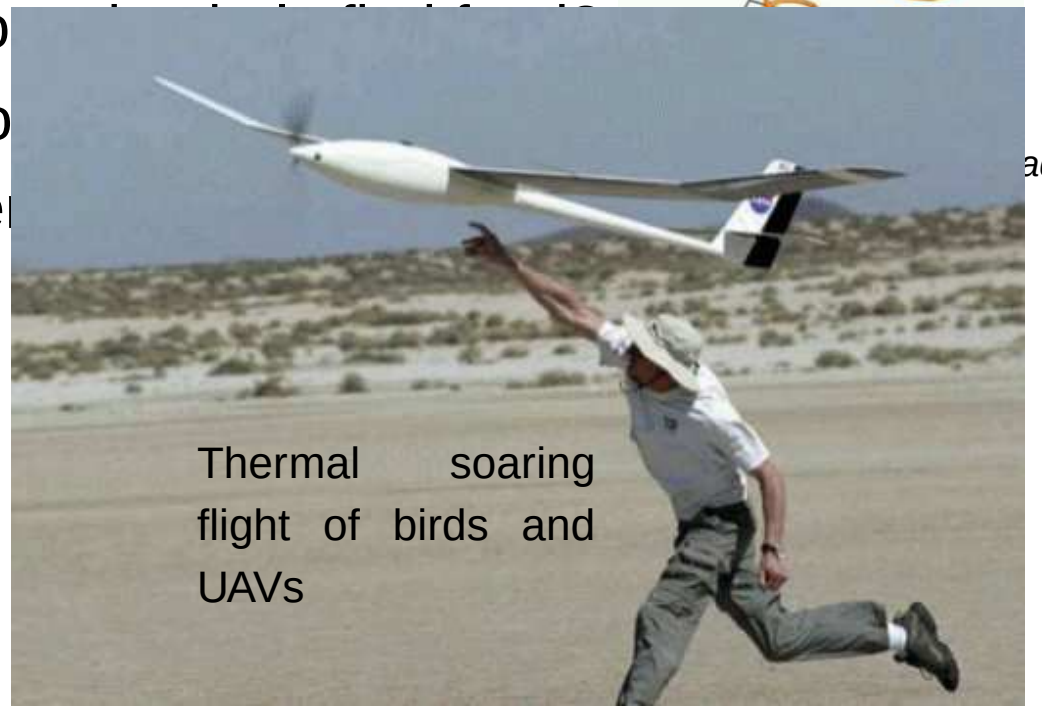

Thermal soaring flight of birds and UAVs

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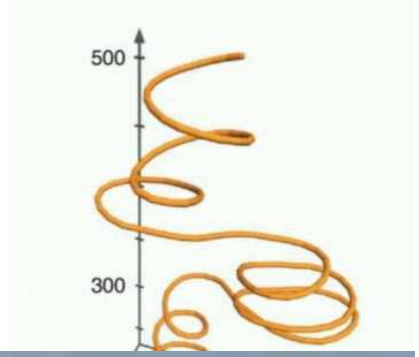

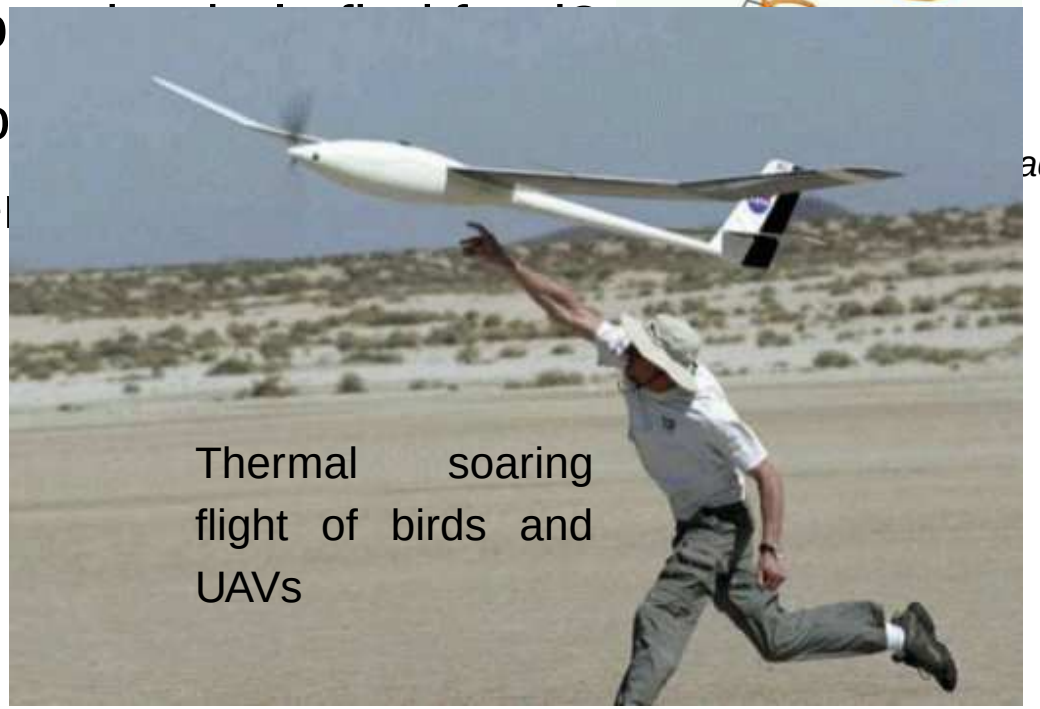

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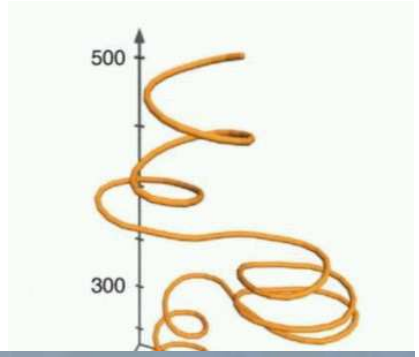

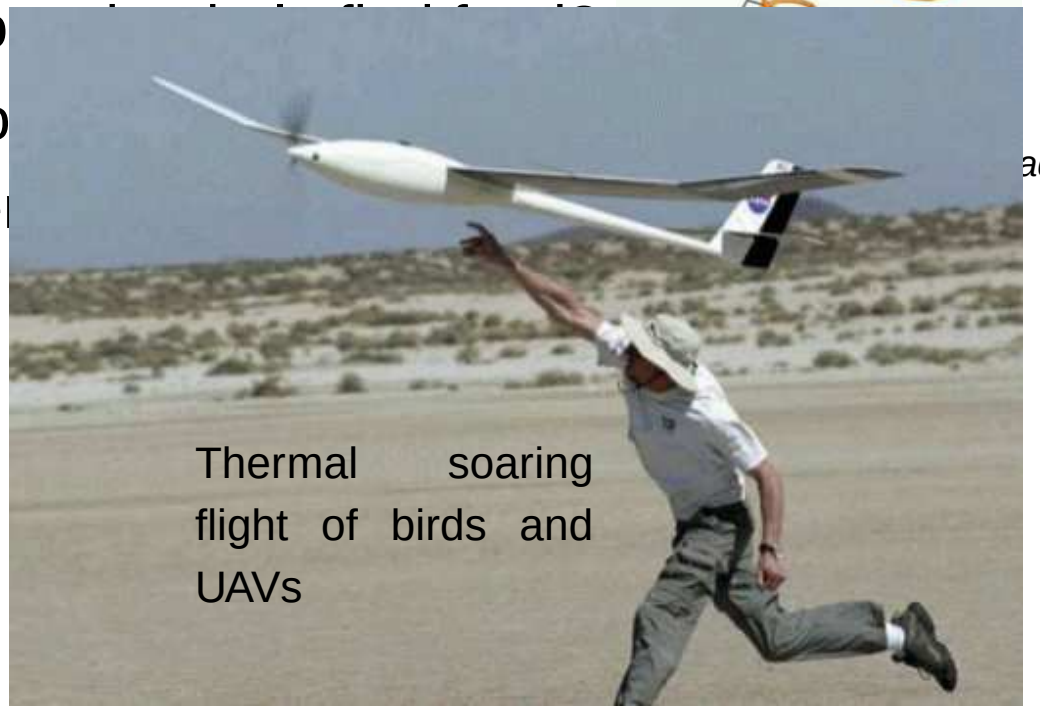

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- Big increase in drones coming in 2015.

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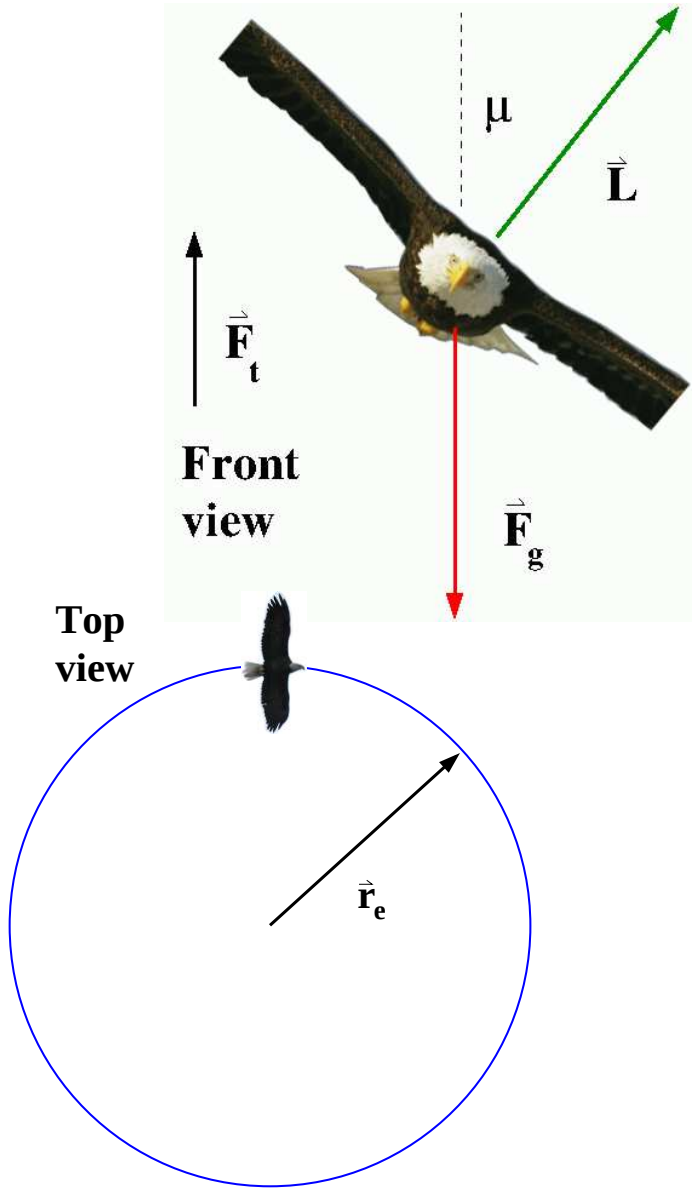
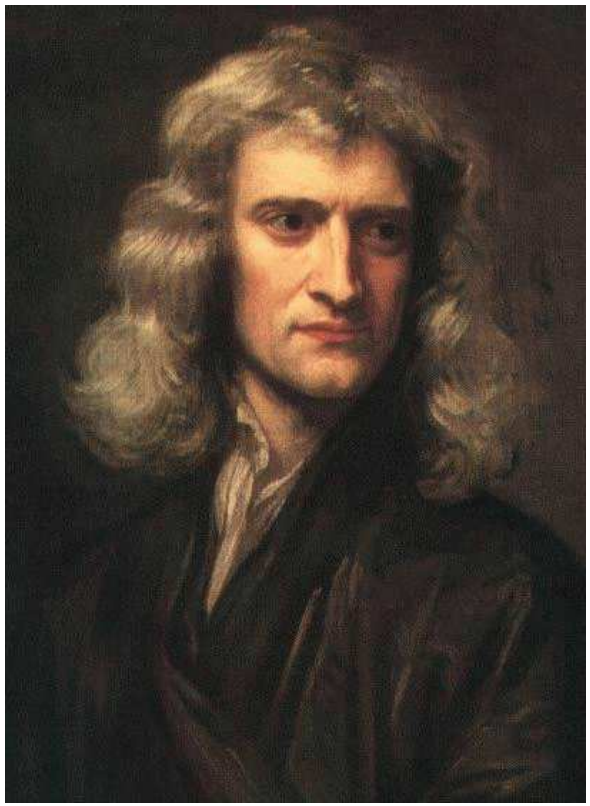
Riding the Thermals

A bald eagle is flying near the James River in search of critters to eat. To stay aloft longer, it orbits in thermals. The eagle has a mass $m_e = 5\ kg$ and can maintain a bank angle $\mu = 40°$ while it orbits (see figure) and a speed $v_e = 14\ m/s$. Its wings exert a lift force $|\vec{L}| = 45\ N$ perpendicular to its velocity and the plane of its wings. The thermal is cylindrical with a radius $r_t = 35\ m$ and exerts a vertical force of $|\vec{F}_t| = 12\ N$ on the eagle. Can the eagle orbit in the thermal without losing altitude? Assume it attempts to fly horizontally.



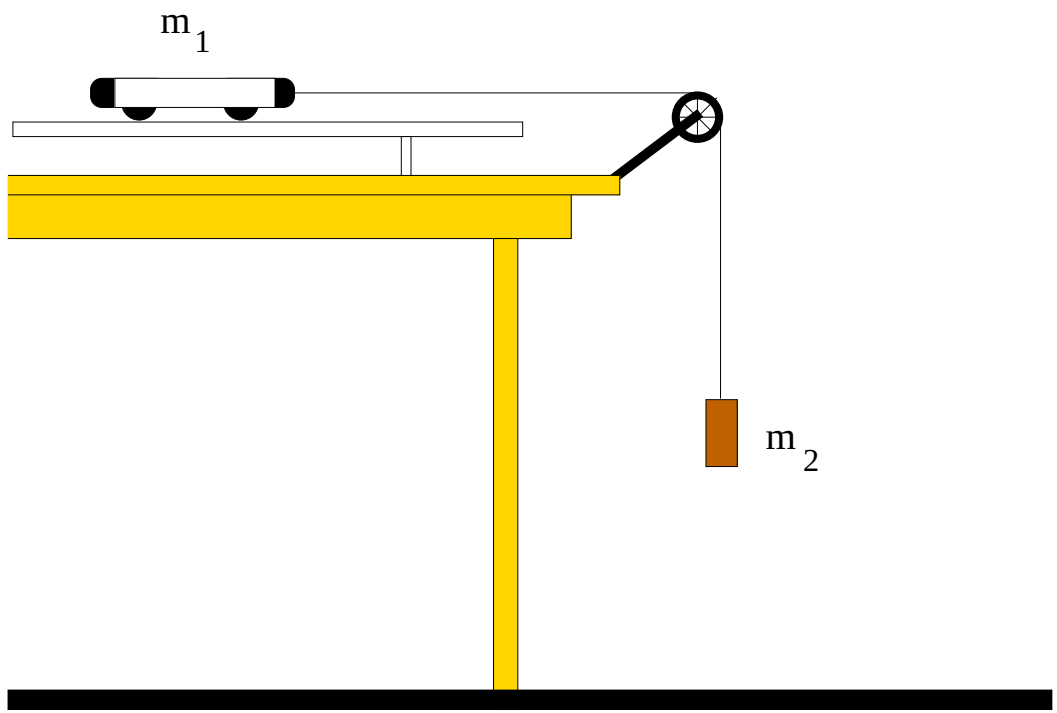
Newton's Laws

1. Consider a body with no net force acting on it. If it is at rest it will remain at rest. If it is moving with a constant velocity it will continue to move at that velocity.
2. For all the different forces acting on a body
$$\Sigma \vec{F}_i = m\vec{a} \quad .$$
3. For every action there is an equal and opposite reaction.
$$\vec{F}_{AB} = -\vec{F}_{BA}$$



Newton's Laws - An Example

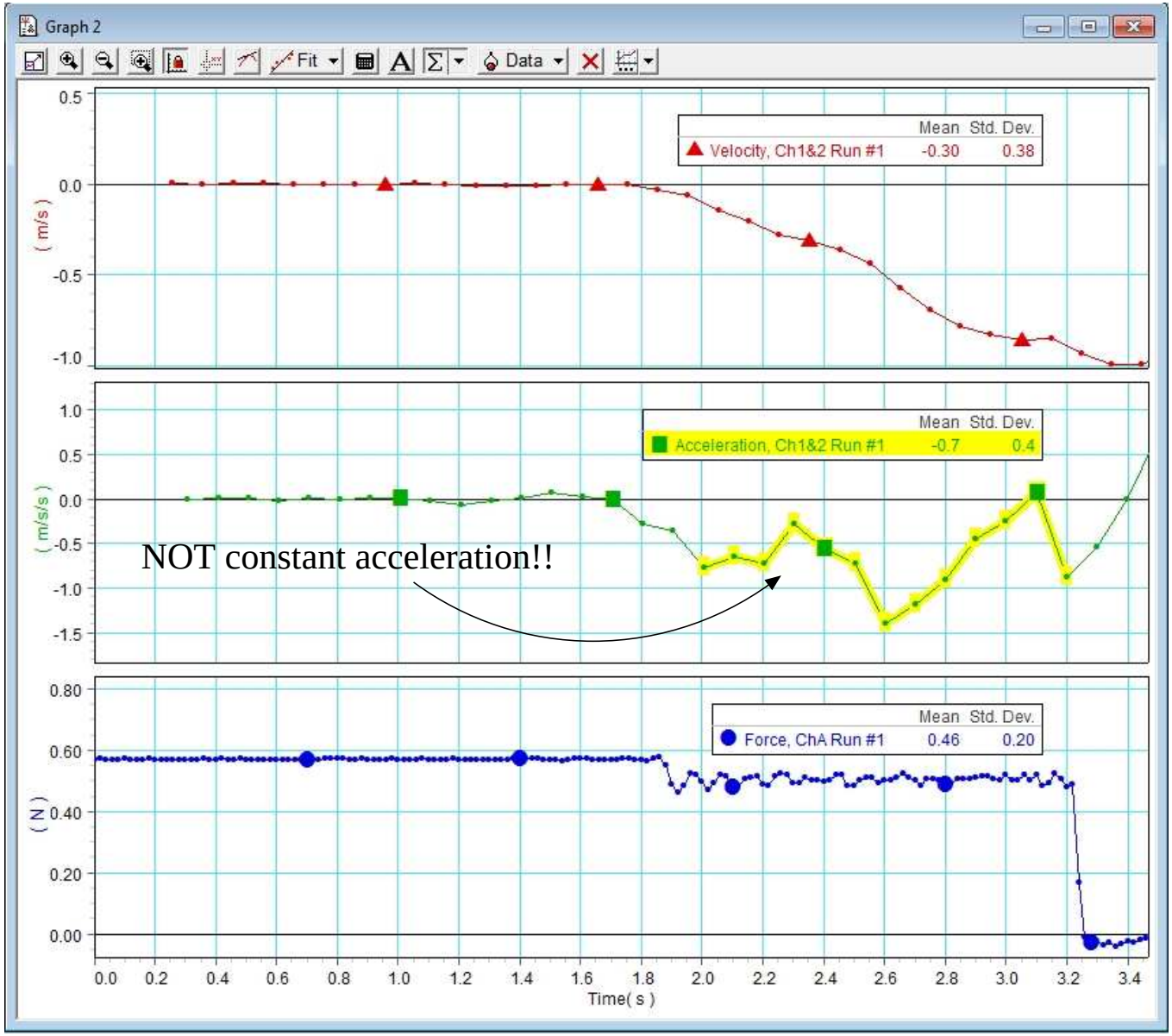
Two blocks are connected by a rope draped over a pulley as shown below. The masses are $m_1 = 1.0\ kg$ and $m_2 = 4.0\ kg$. What is the acceleration of both masses?



Combining Forces On A Falling Balloon

A hot-air balloon of mass M is descending vertically with a downward acceleration a as shown below. How much ballast m_b must be thrown out to give the balloon the same magnitude acceleration in the opposite direction (up)? Assume the upward force of the hot air does not change as ballast is dropped and express your answer as an equation in M, a, and any necessary constants.

Force and Motion



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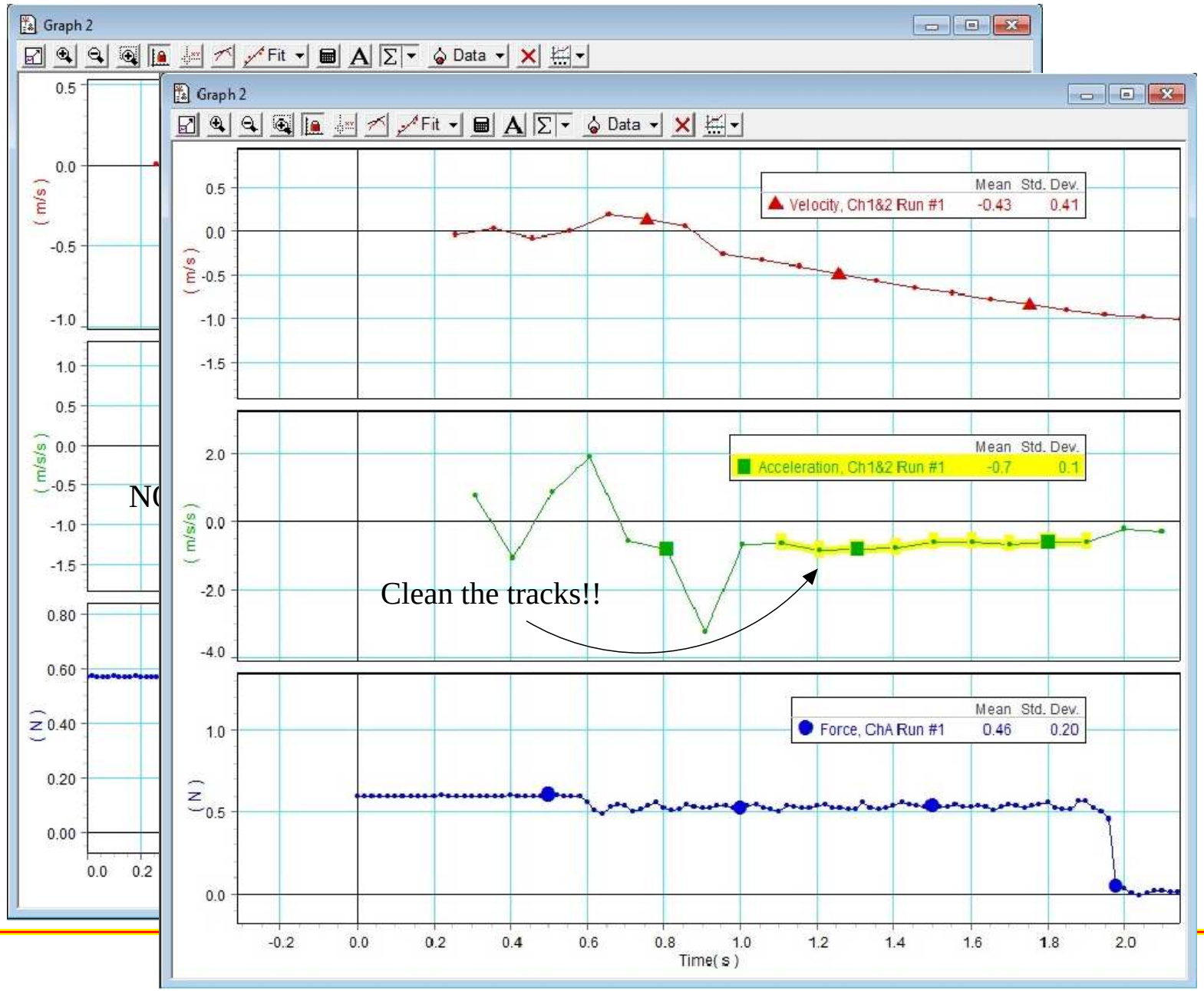

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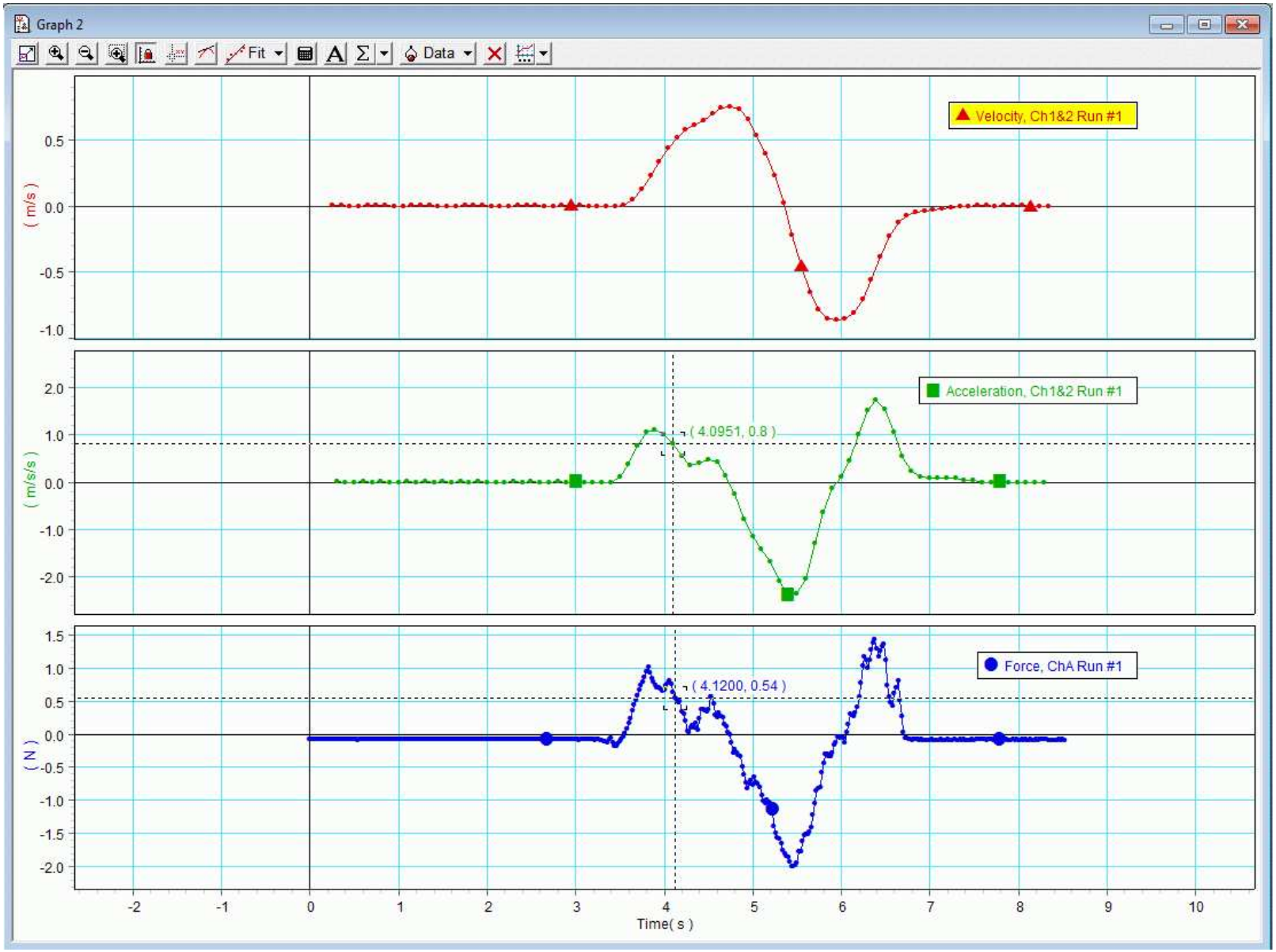

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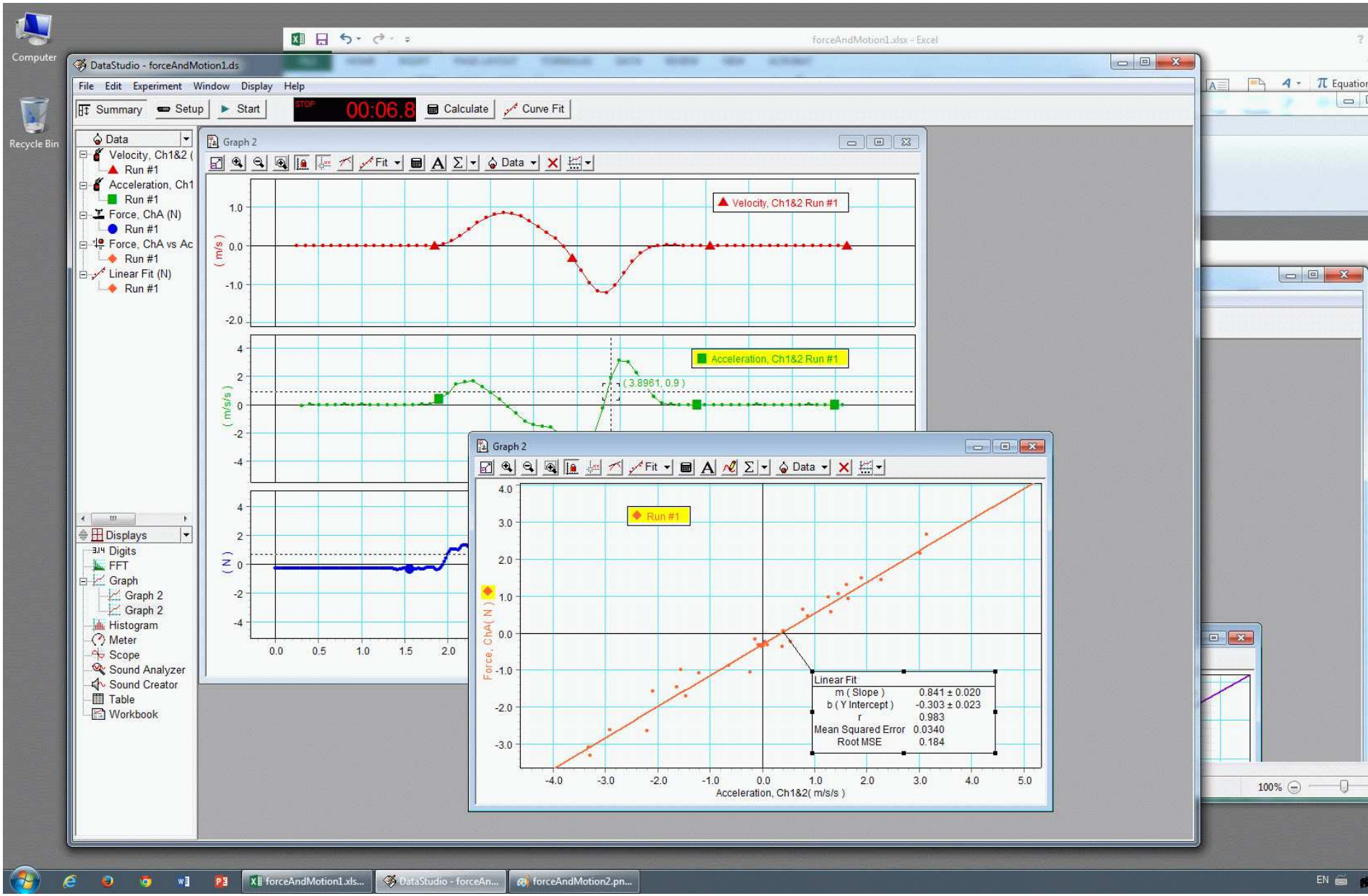

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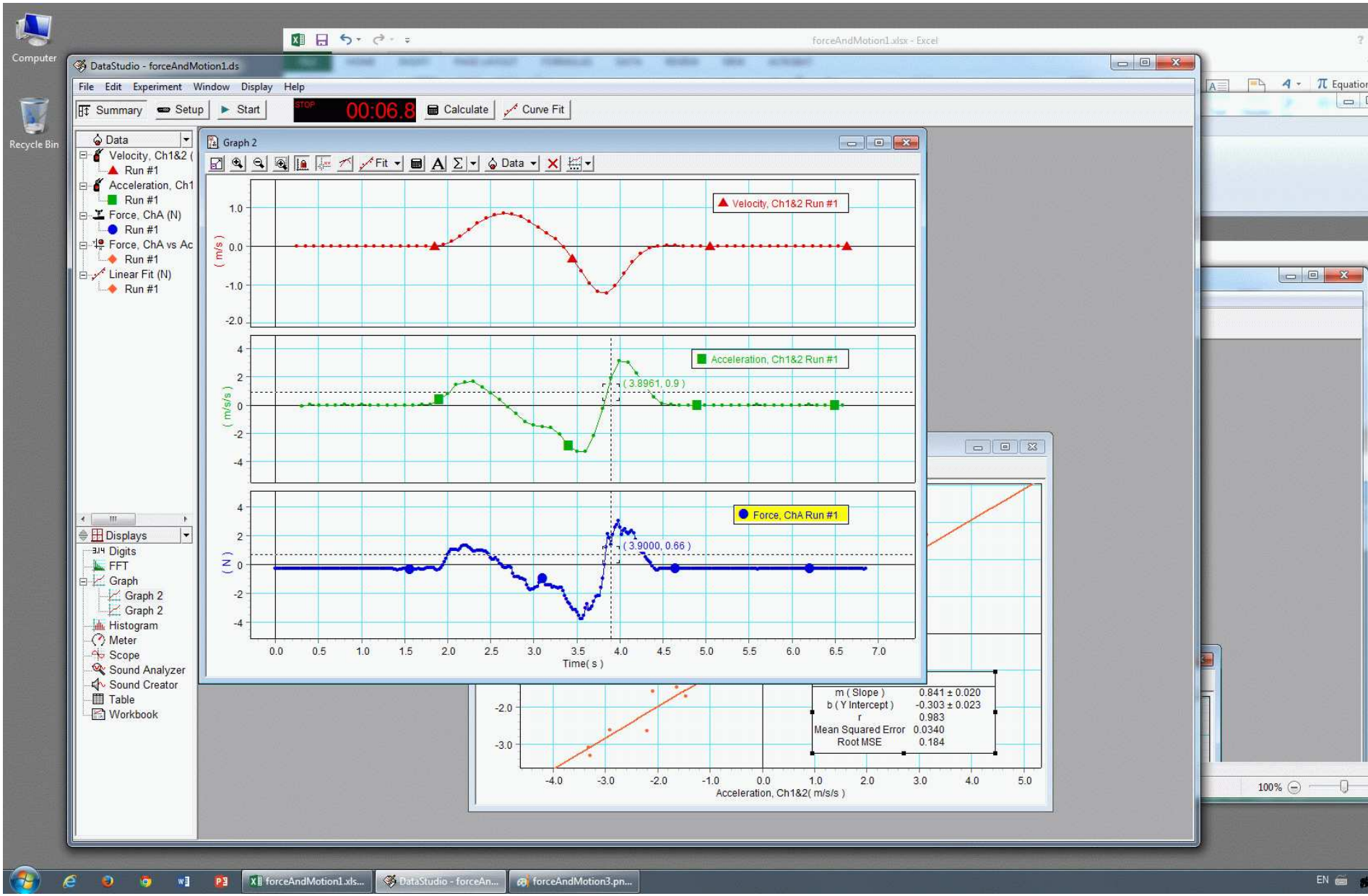

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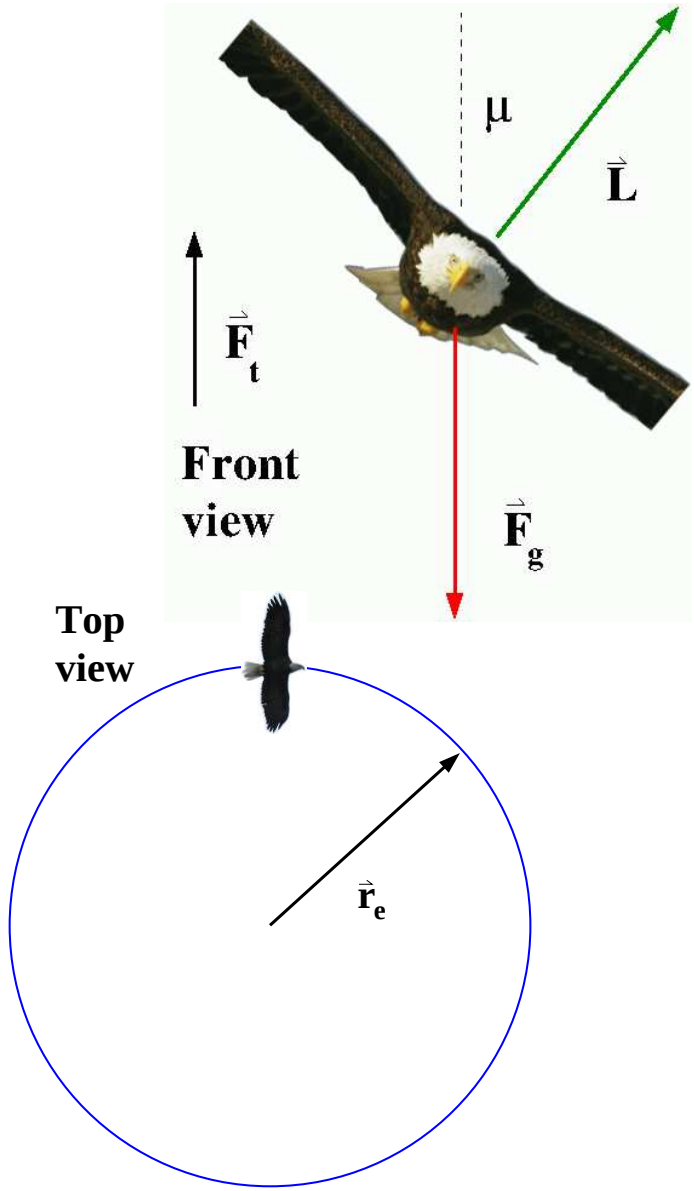

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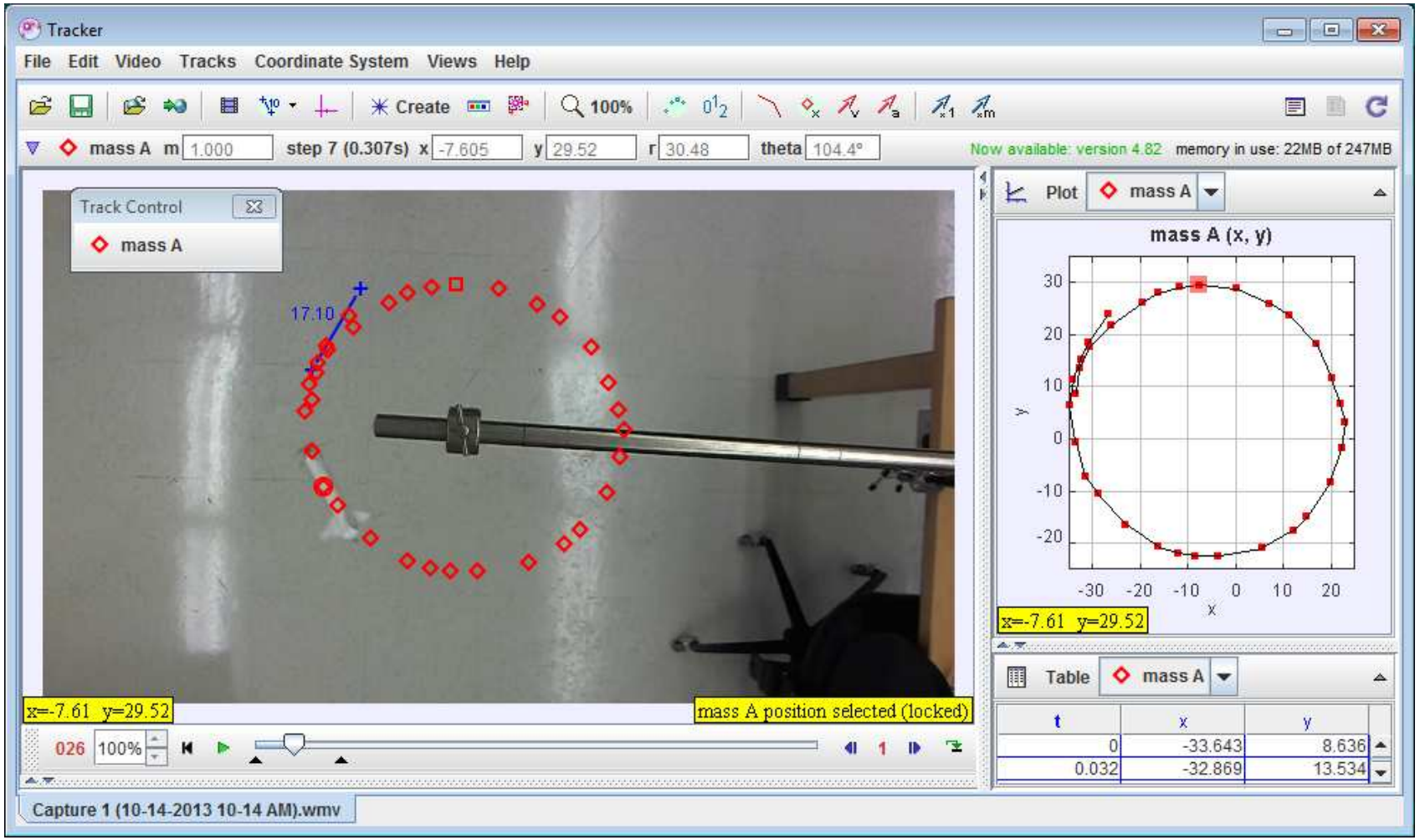

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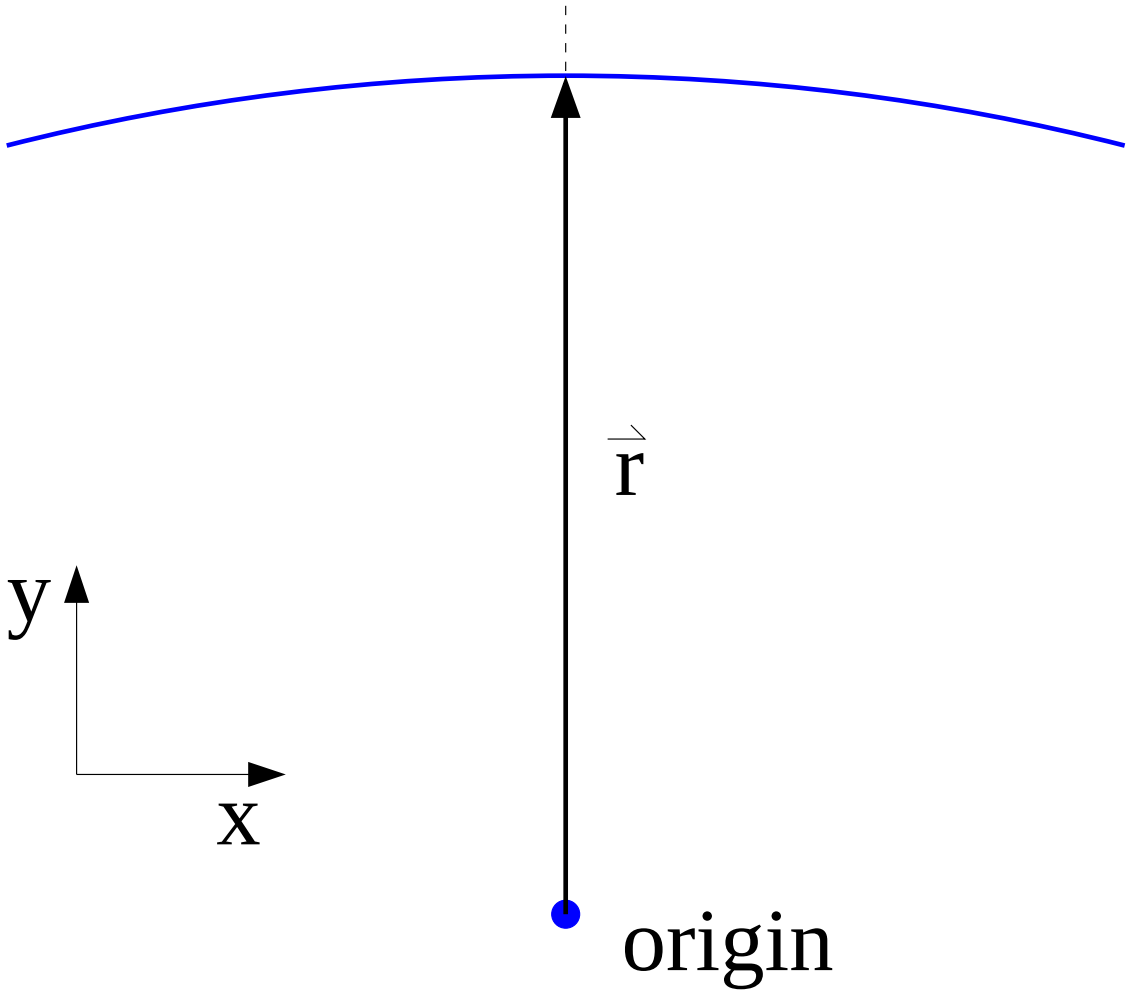
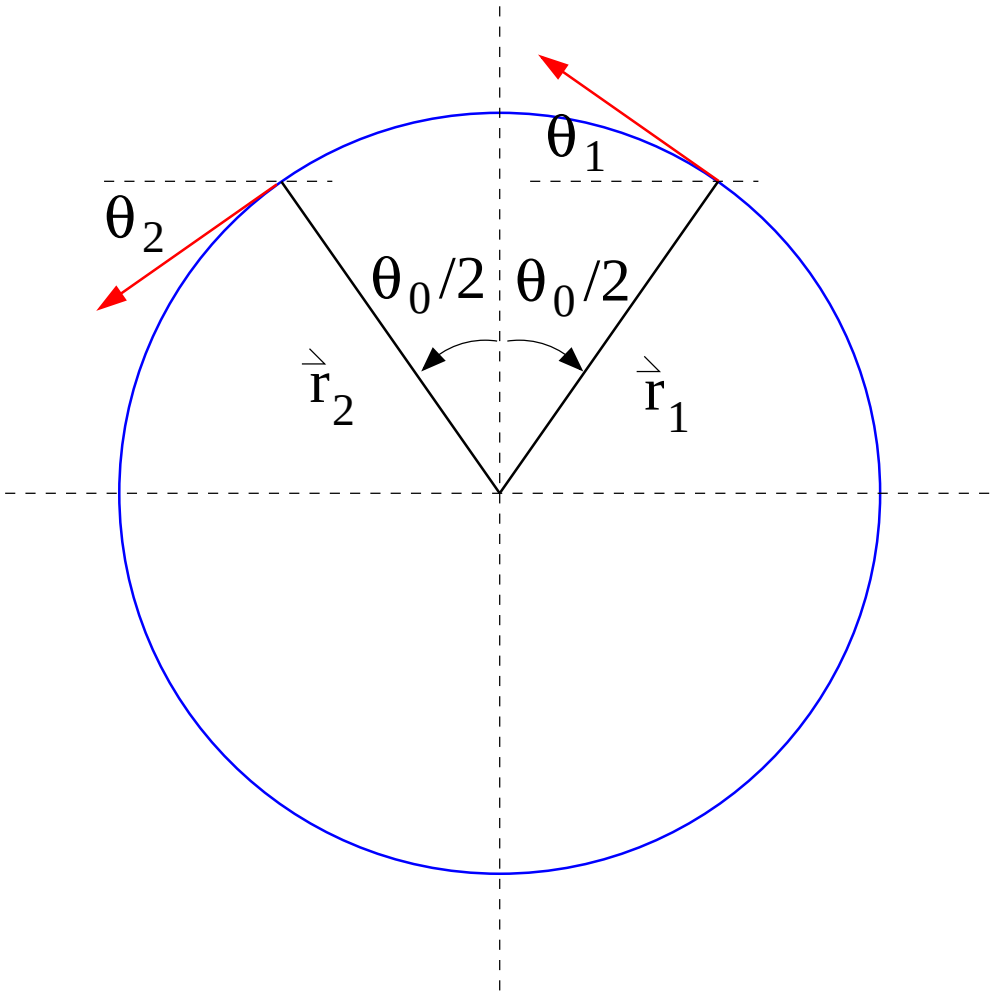


Circular Motion - 3



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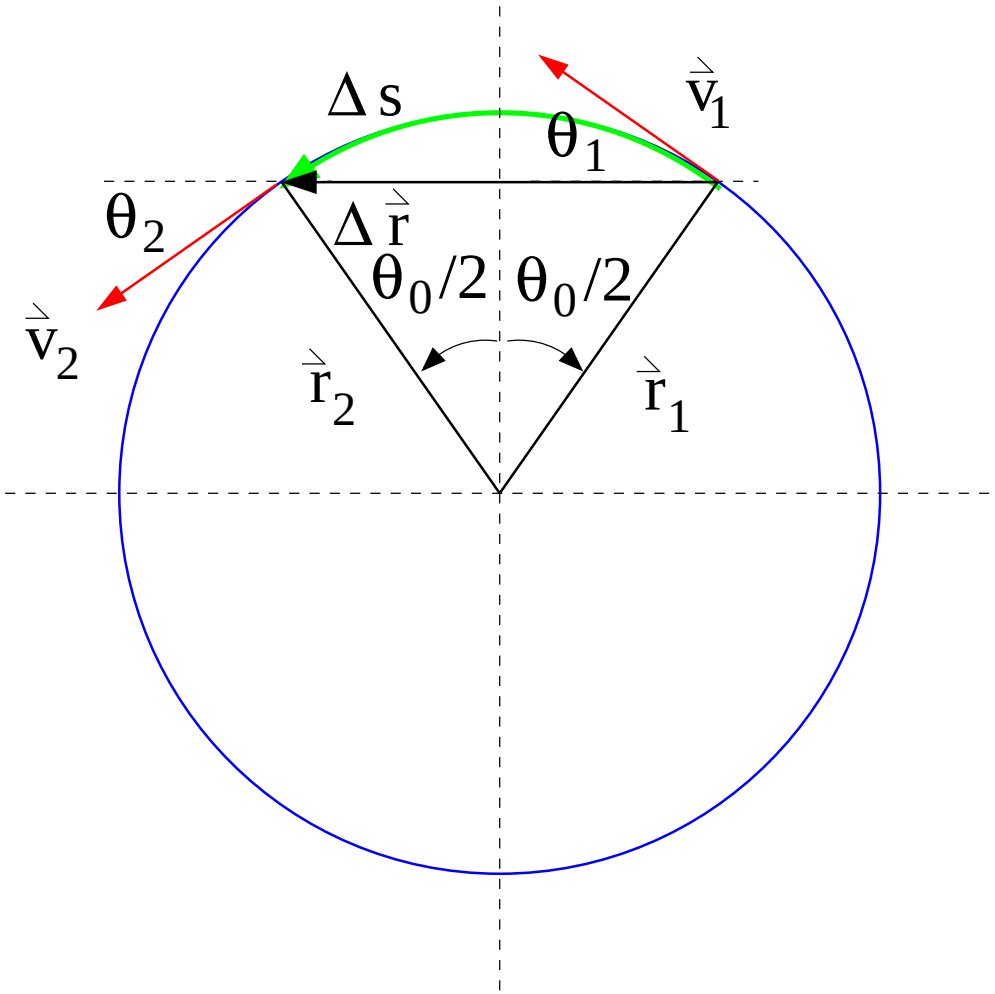

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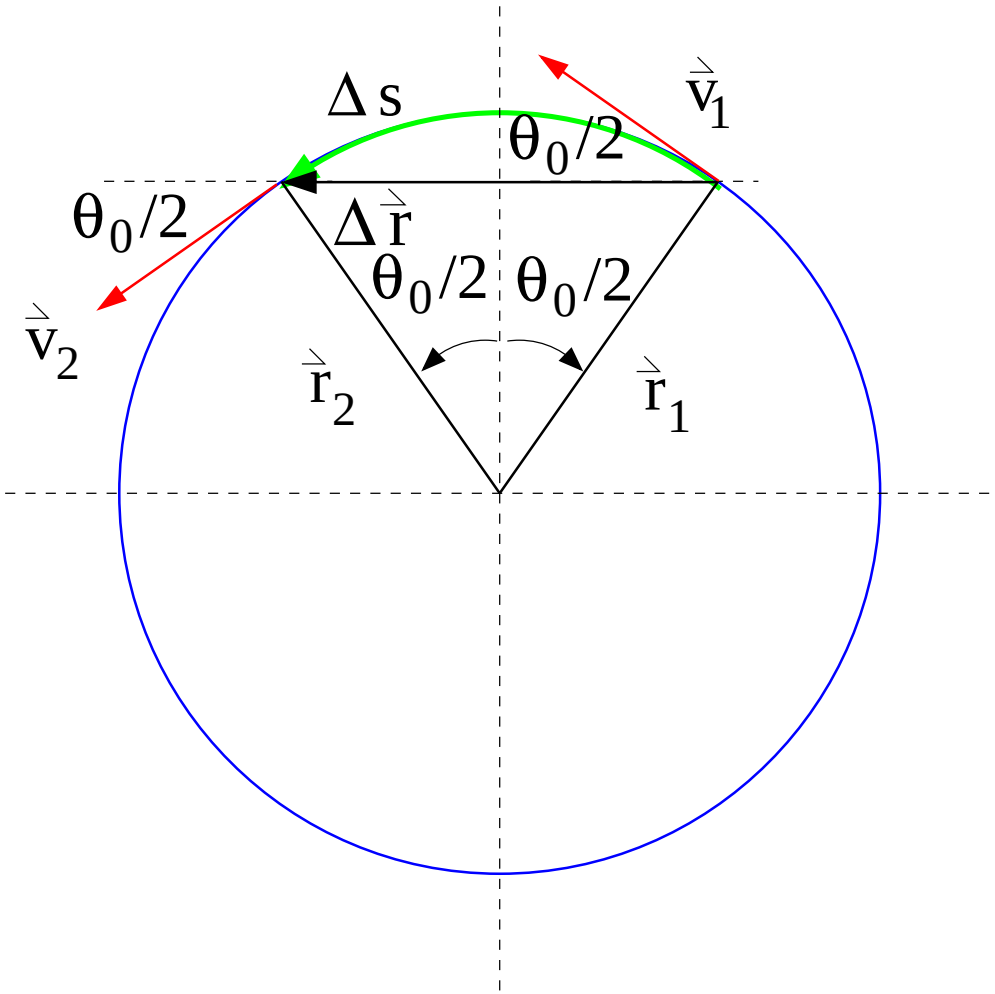

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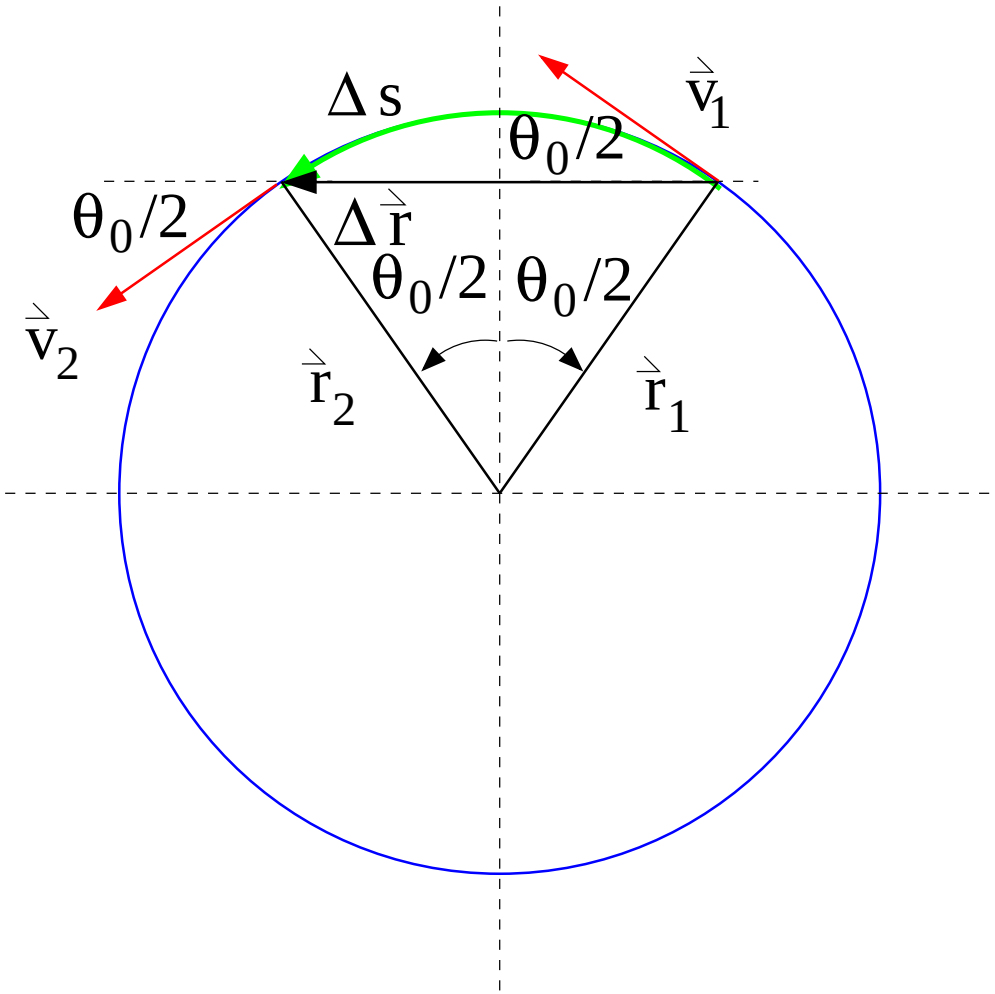

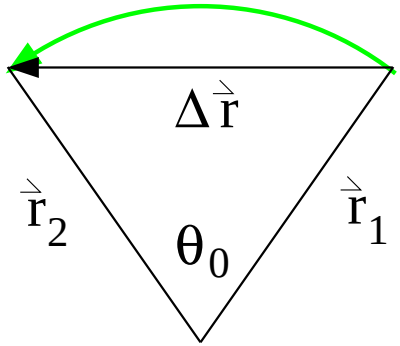

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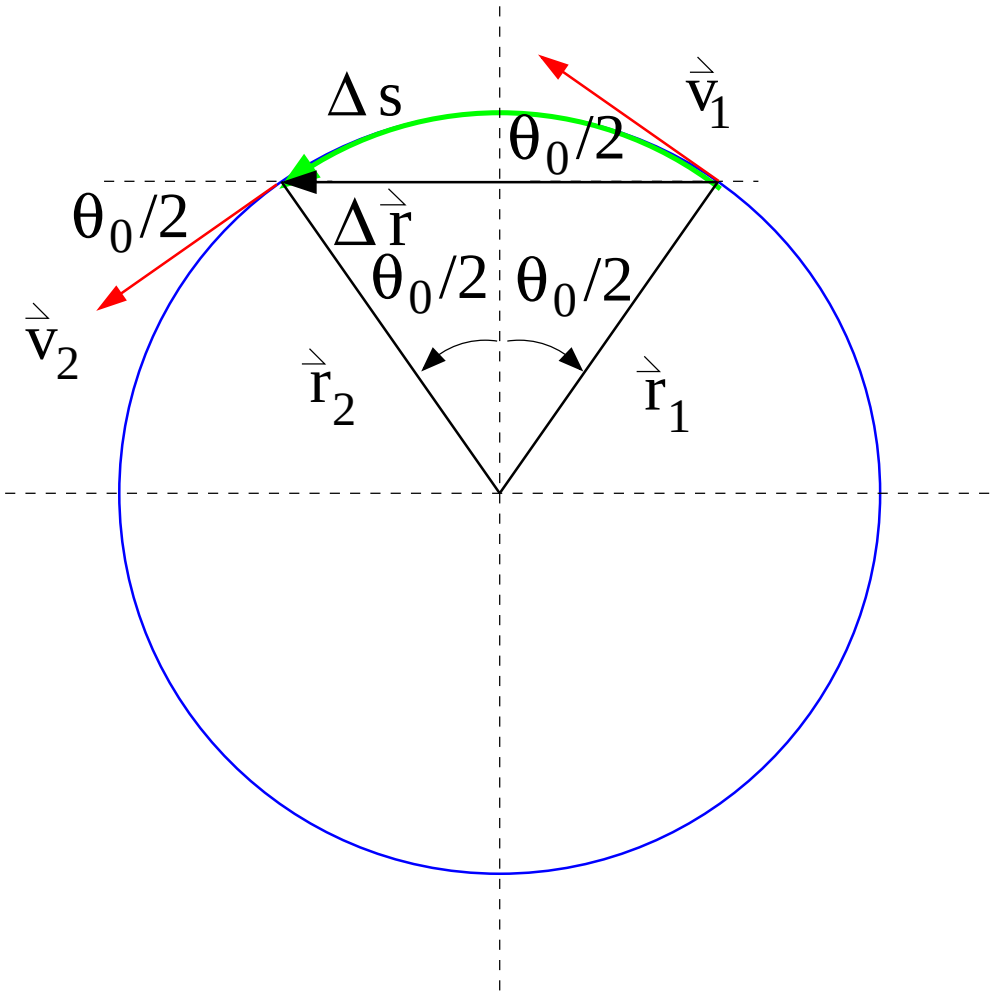

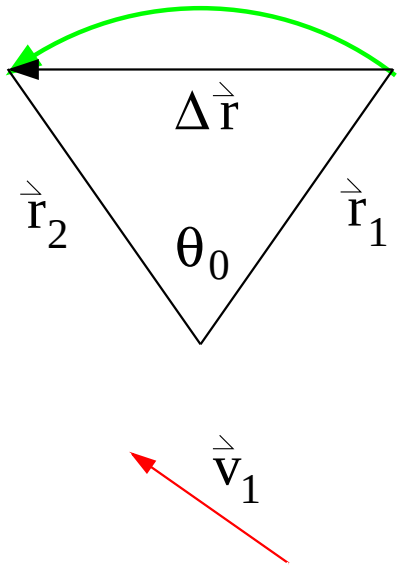

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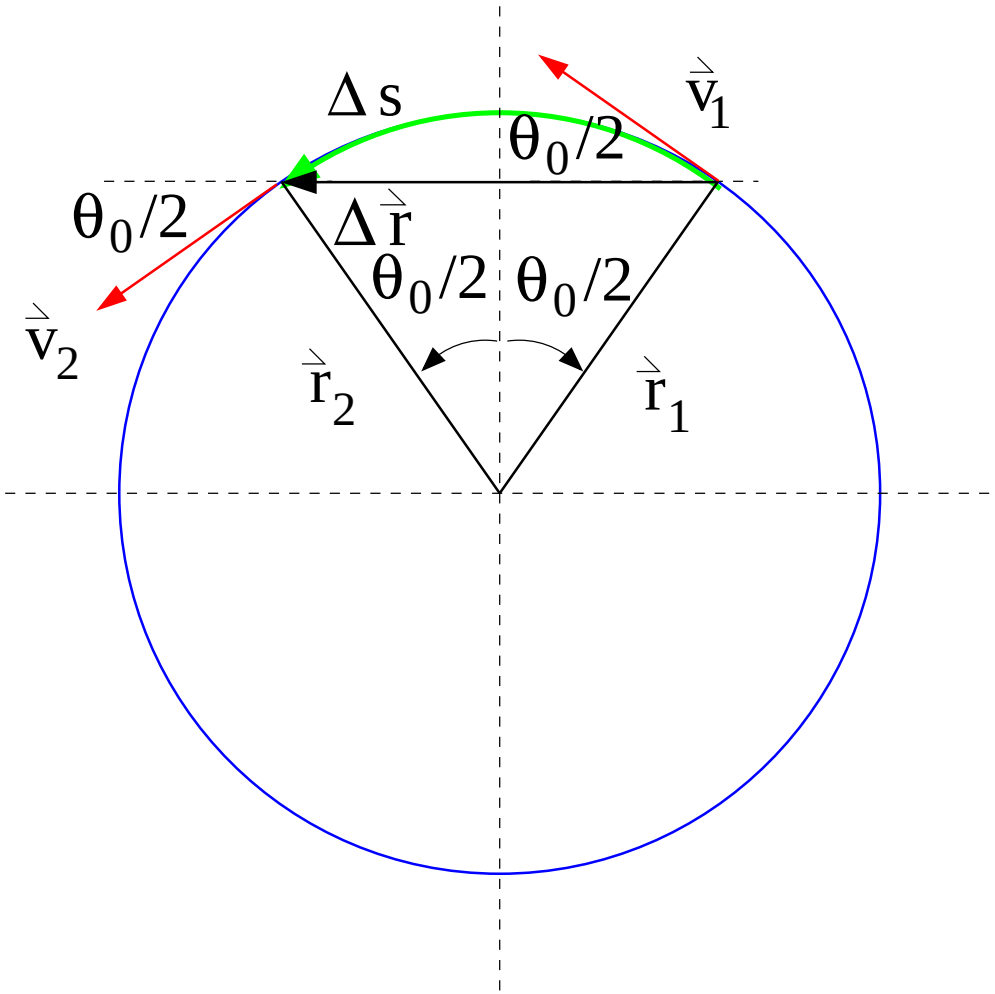

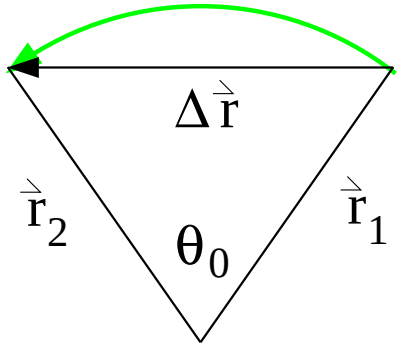

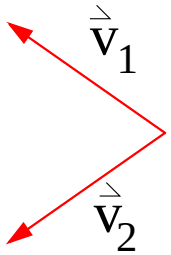

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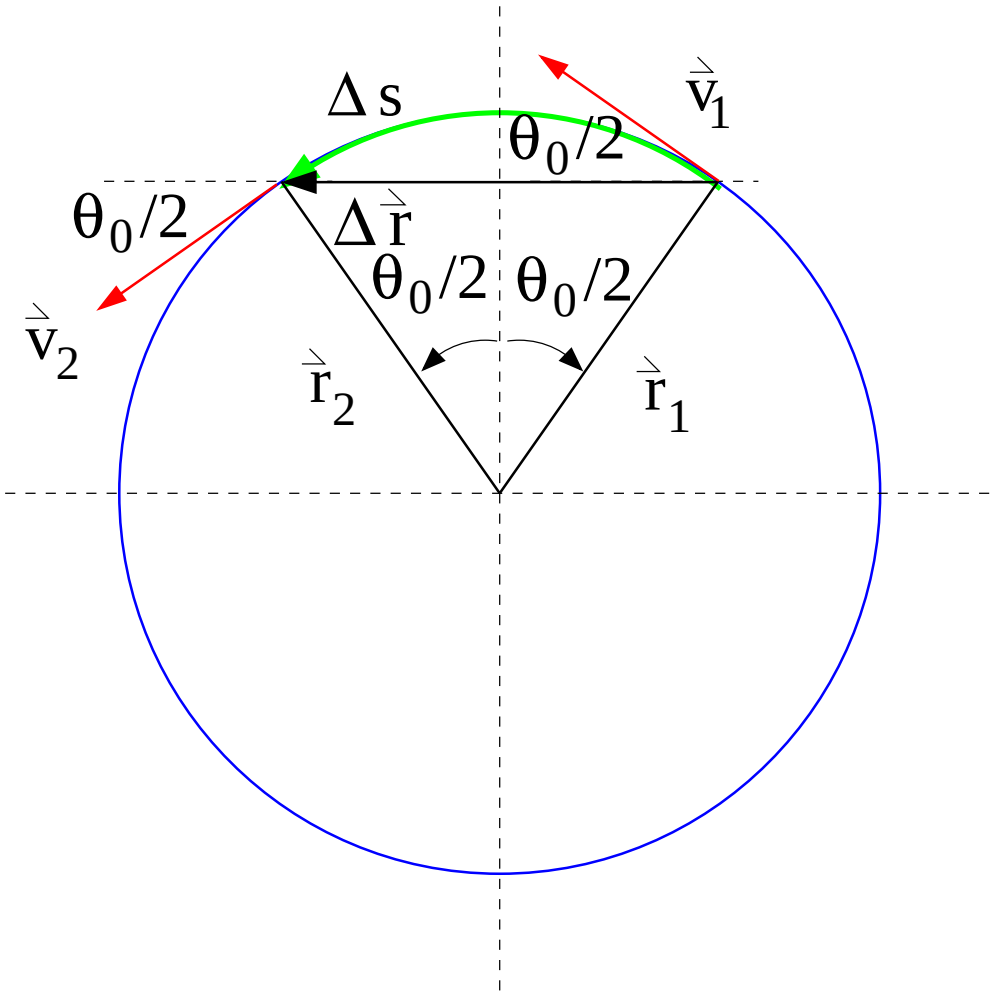

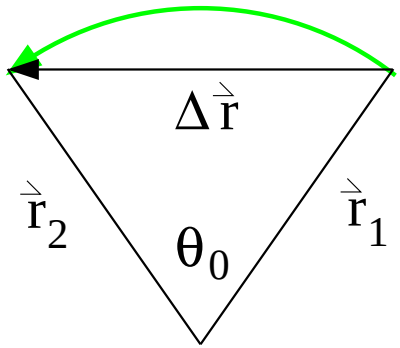

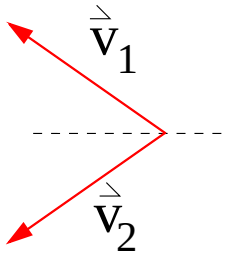

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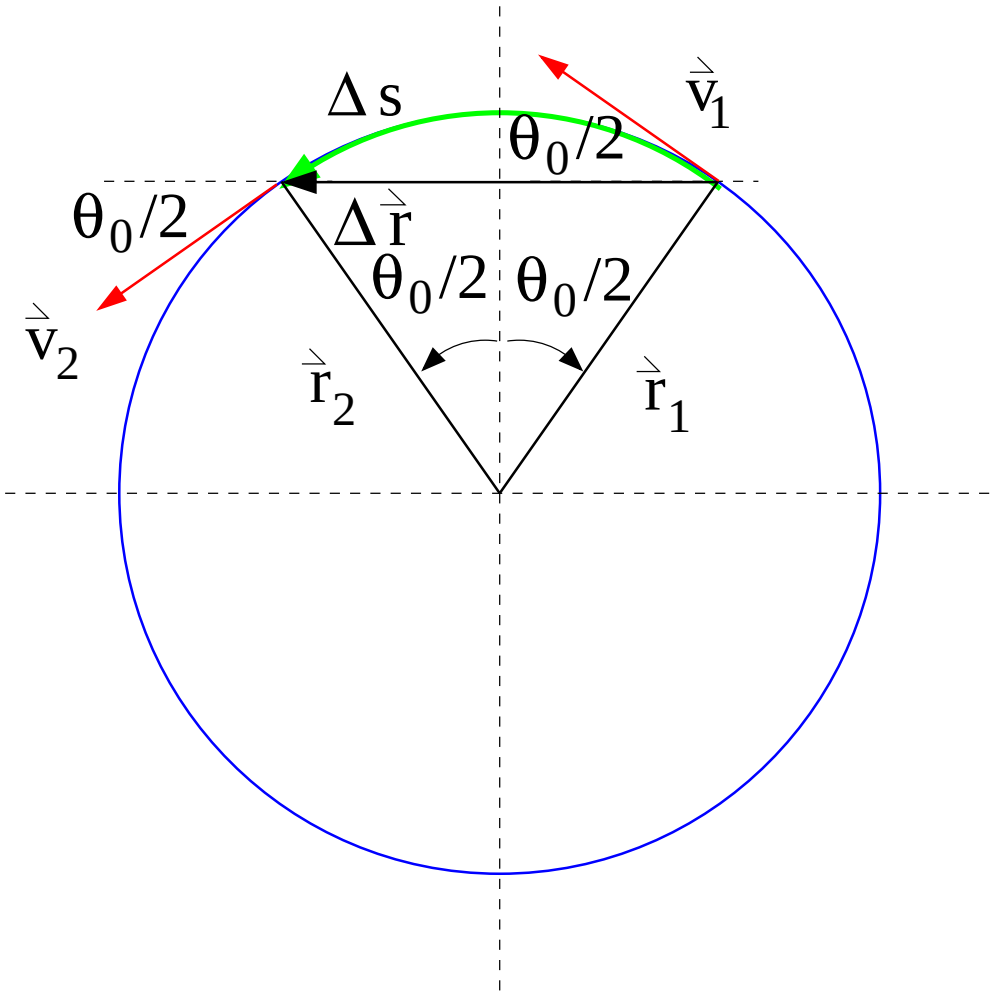

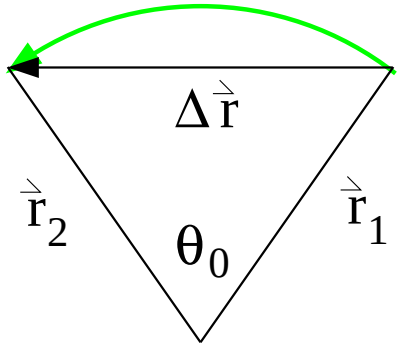

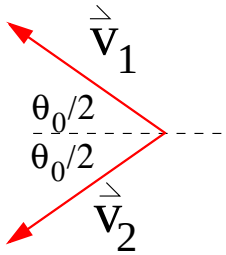

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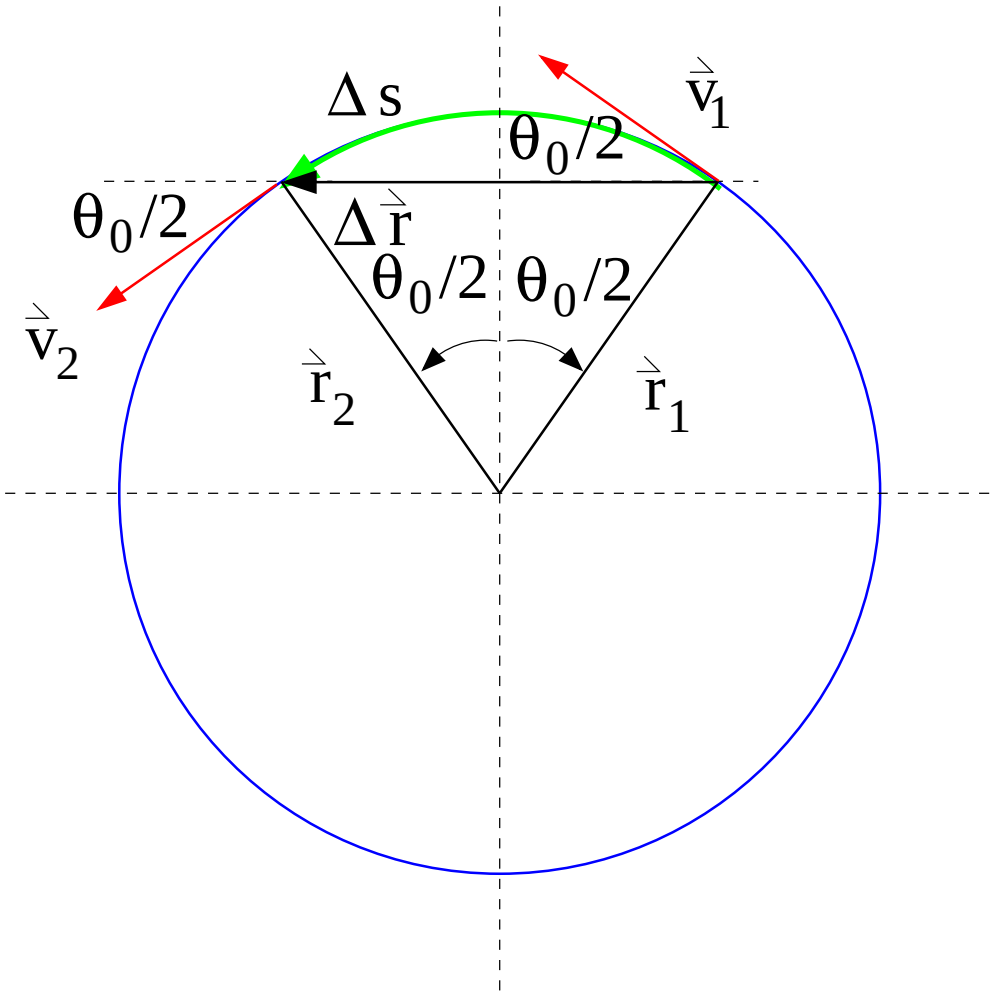

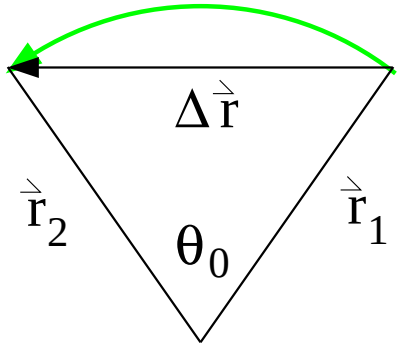

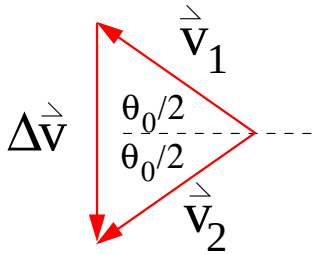

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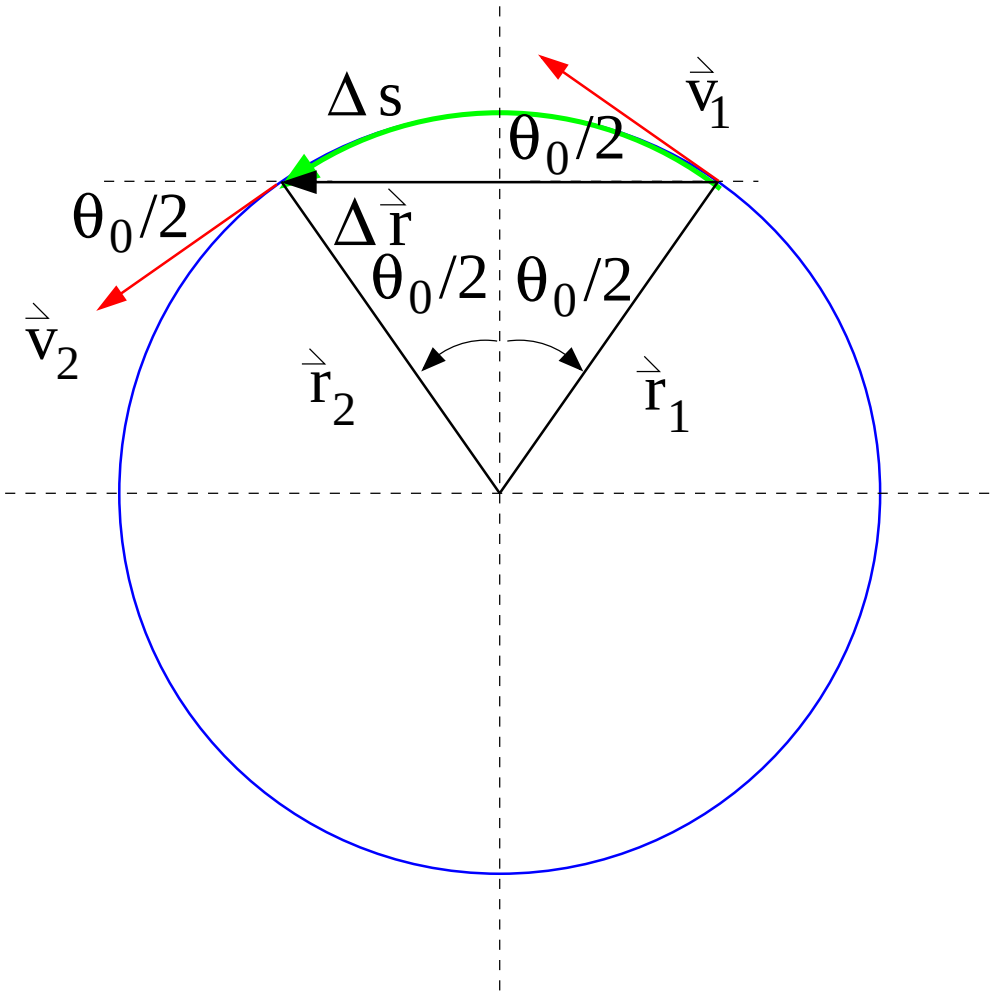
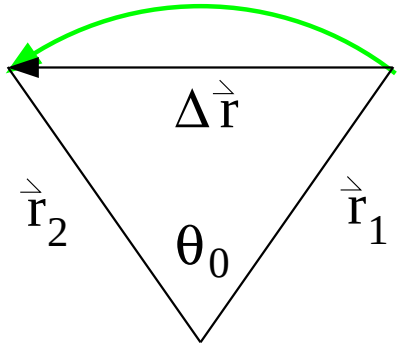
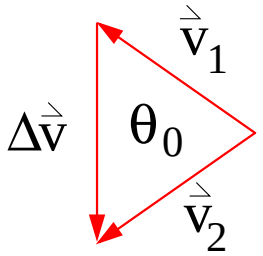
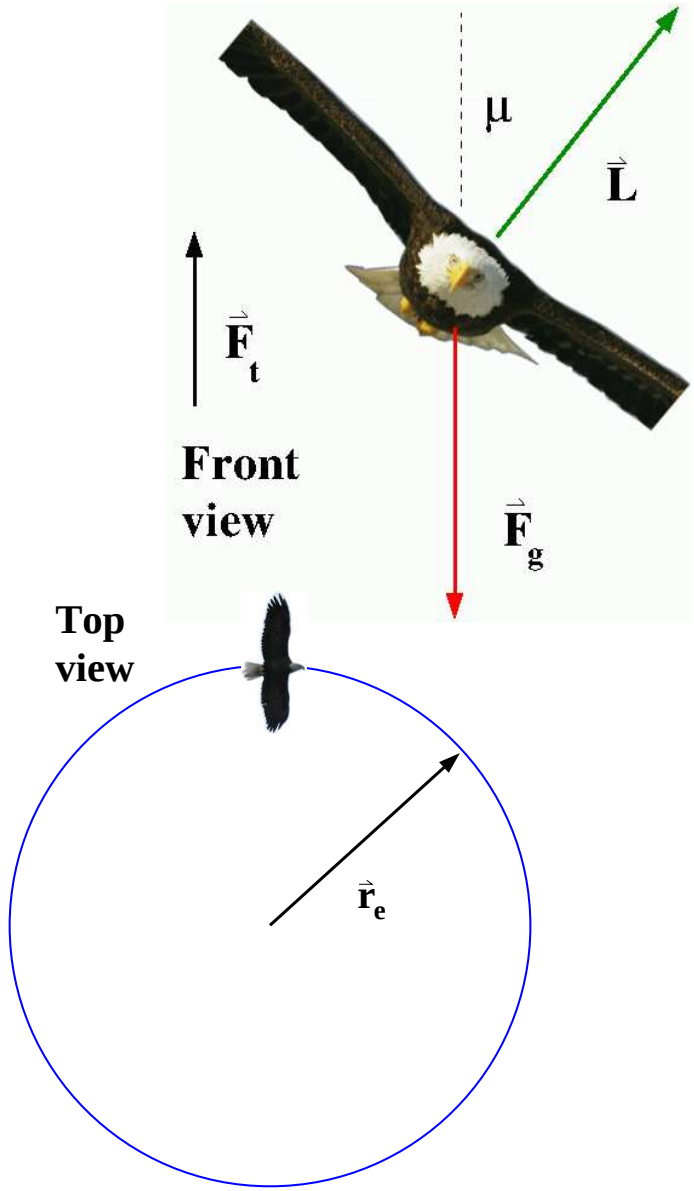




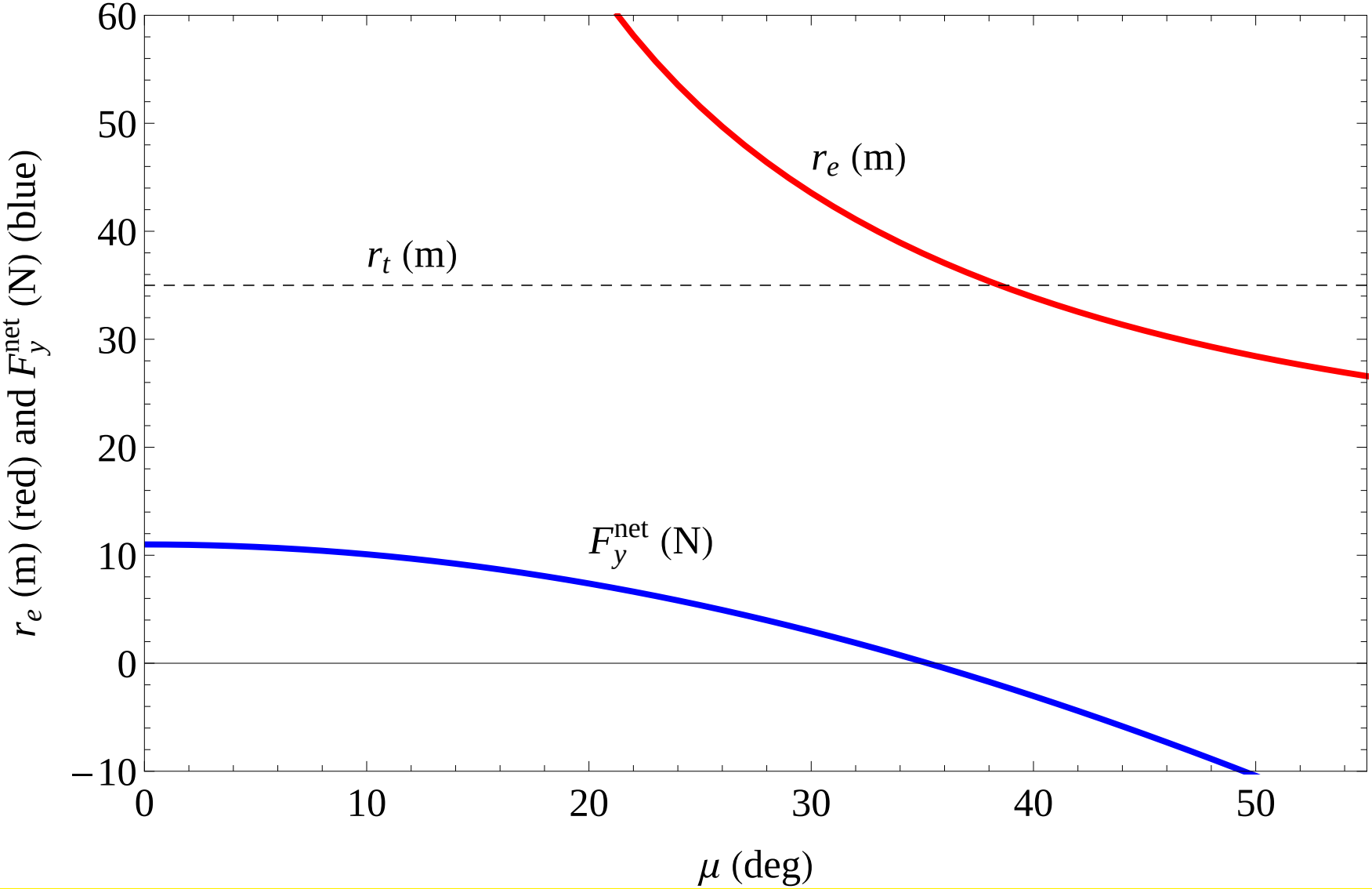


Riding the Thermals

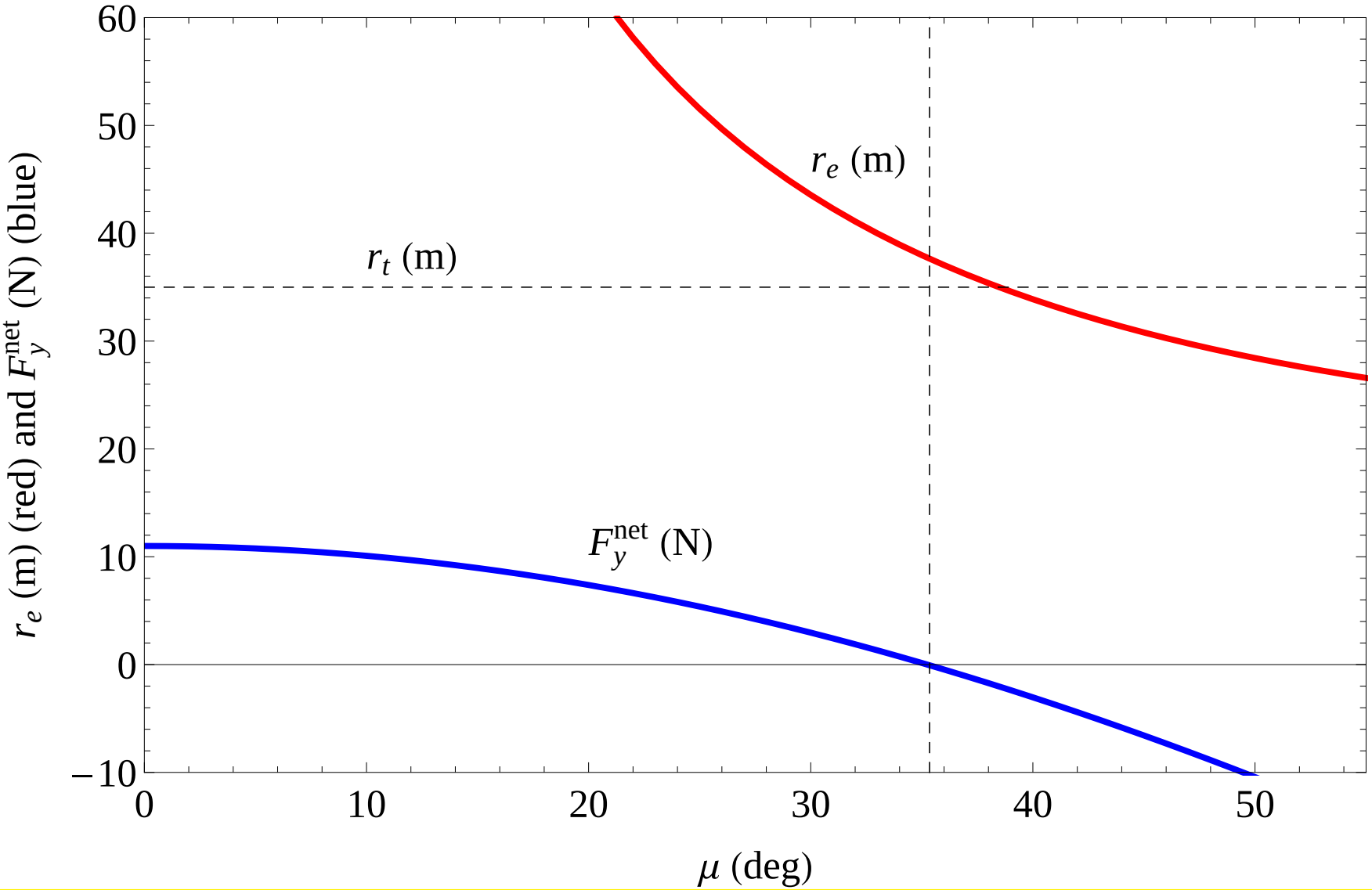
A bald eagle is flying near the James River in search of critters to eat. To stay aloft longer, it orbits in thermals. The eagle has a mass $m_e = 5\ kg$ and can maintain a bank angle $\mu = 40°$ while it orbits (see figure) and a speed $v_e = 14\ m/s$. Its wings exert a lift force $|\vec{L}| = 45\ N$ perpendicular to its velocity and the plane of its wings. The thermal is cylindrical with a radius $r_t = 35\ m$ and exerts a vertical force of $|\vec{F}_t| = 12\ N$ on the eagle. Can the eagle orbit in the thermal without losing altitude? Assume it attempts to fly horizontally.



Does the Eagle Make It?



Does the Eagle Make It?



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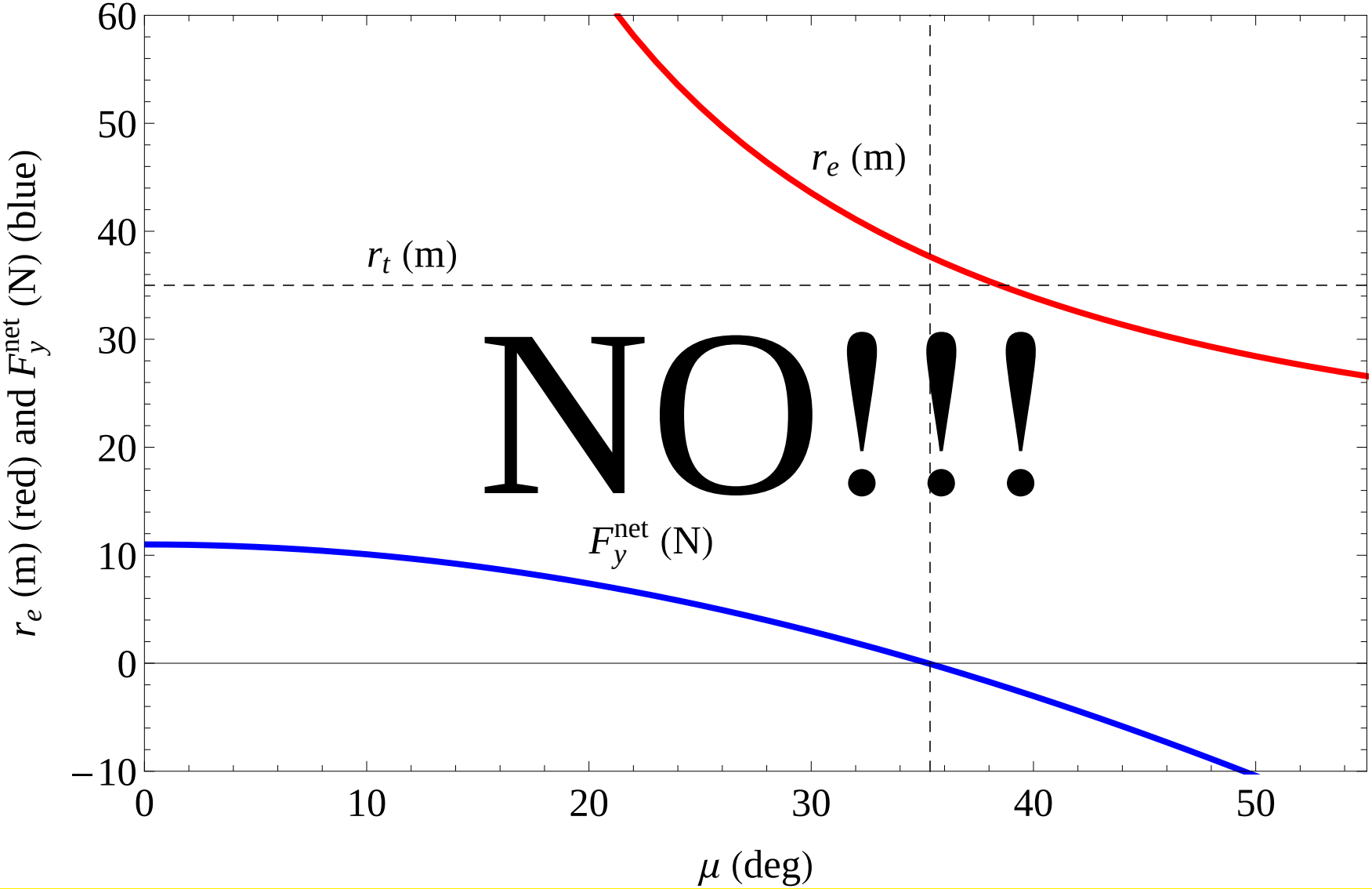
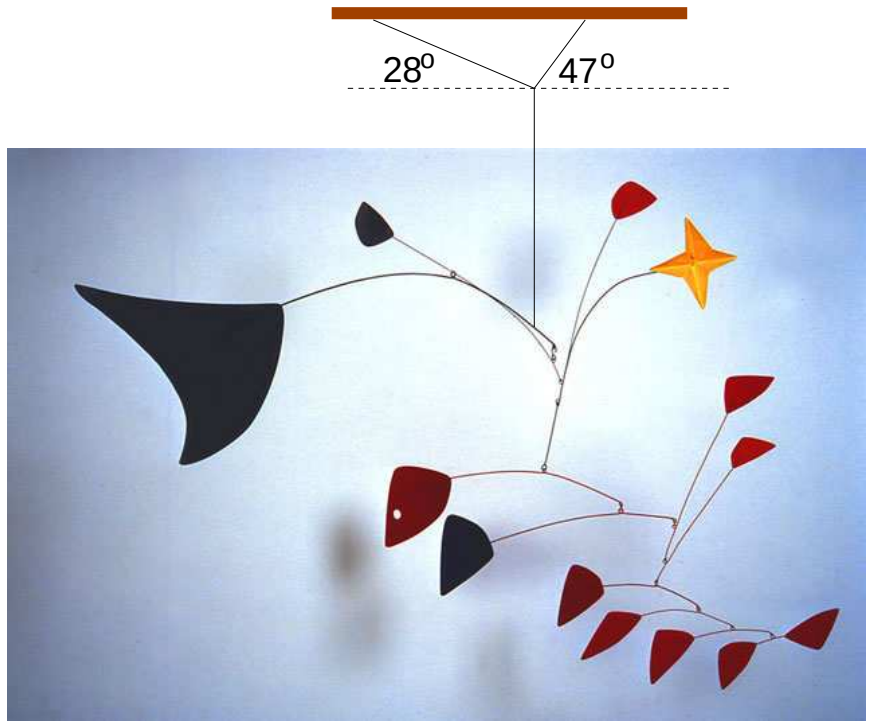


Additional Slides

Liberal Arts!!

You are an engineer who has to hang a kinetic sculpture (a mobile) by the famed artist Alexander Calder from the crossbeams of the hall of an art gallery. Consider the two cables used to hold up the mobile of mass $m = 80\ kg$ from a ceiling as shown below. They are attached at two separate points on the ceiling as shown. What is the tension in each cable?



ALEXANDER CALDER
(American, 1898-1976)
The Star, 1960
Polychrome sheet metal and steel wire
35-3/4 x 53-3/4 x 17-5/8”

The Rotor

The Rotor is an amusement park ride in which a room shaped like a cylinder is spun rapidly forcing the occupants to lean against the wall. When a minimum rotational frequency is reached the floor of the room is suddenly dropped. Of course, the riders remain safely pinned to the walls of the spinning room. What is the minimum rotational frequency for this ride to work properly? The radius of the room is $r = 2.1\ m$ and the coefficient of friction between the walls and the backs of the riders is $\mu = 0.4$.

Coefficients of Friction

Materials	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete	1.0	0.8
Wood on wood	0.25-0.5	0.2
Glass on glass	0.94	0.4
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	-	0.04
Ice on ice	0.1	0.03
Teflon on Teflon	0.04	0.04
Human synovial joints	0.01	0.003

The Rotor

The Anaconda is a popular roller coaster at the King's Dominion amusement part north of Richmond. It contains a loop in it's track like the one shown below. If the radius of the loop is $R = 6.3\ m$, then what is the minimum speed at the top of the loop that is necessary to prevent someone from falling out?

Newton's Third Law

A farm worker pulls a cart with a force $\vec{F}_f$. Newton's third law states that the wagon exerts and equal and opposite force on the worker $-\vec{F}_f$. Hence, the wagon remains stationary.

Is this statement correct? Explain.

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That Professor Goddard with his 'chair' in Clark College and the countenancing of the Smithsonian Institution does not know the relation of action to reaction, and of the need to have something better than a vacuum to react against - to say that would be absurd. Of course, he only seems to lack the knowledge ladled out daily in the high schools.

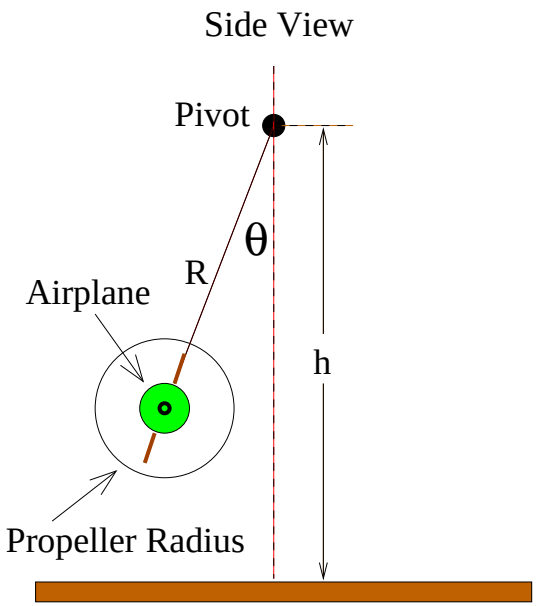
editorial in the *New York Times*
January 13, 1920

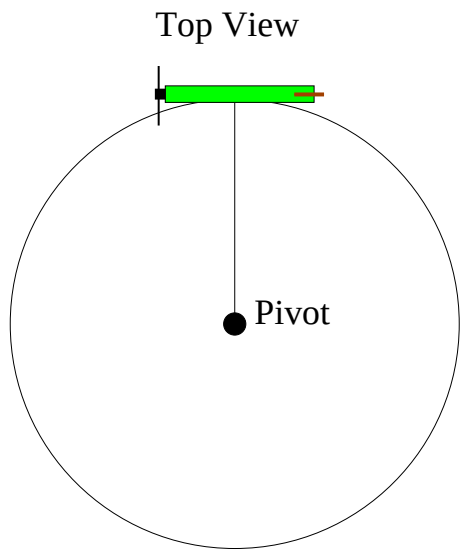
Airplanes on a String

Consider the model airplane hanging from a string and flying in a circle as shown in the figure. The velocity of the plane is $v = 1.2\ m/s$. What is the tension in the string?

Some useful information

Mass (m)	$0.2\ kg$
Vertical Angle(θ)	$25°$
String length(R)	$0.7\ m$
Pivot height(h)	$1.3\ m$





Hints for the Centripetal Force lab

1. Align the camera, string, and the plane in the center of the camera's field of view.
2. Use the distance from the hole in the post the string passes through, along the string, to the center of the airplane.
3. The distance in Number 2 should not exceed 45 cm.
4. Let the airplane run for about one minute before taking data to let any oscillations die out.
5. Weigh the plane on the scale.
6. Measure the diameter along the horizontal and vertical axes of your Excel plot. If they are significantly different, consult your instructor.