Do You Need a Lawyer? 1

You are a recent Richmond physics graduate and get this cool job working for an outdoor recreation equipment company. Your boss is getting a sales pitch for a new bungee jumping system to be used on Bridge Day at the New River Gorge Bridge in West Virginia. She turns to you and says "Is it safe? Will we get sued".

Model the bungee cord as a spring. The parameters are below where h is the height of the bridge, $\mathcal{L}$ is the unstretched length of the bungee cord and k is its spring constant.

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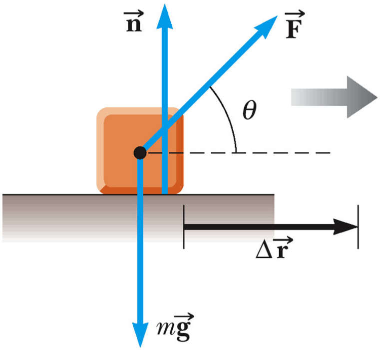
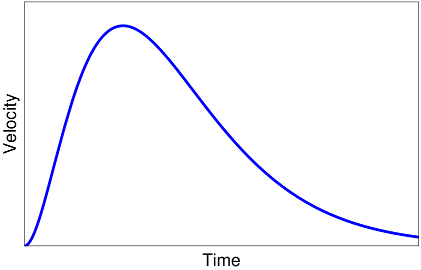
Well?

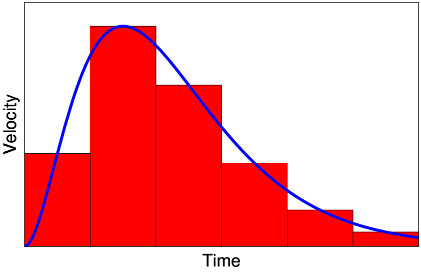
A cart is pulled across a flat surface with a rope at an angle $\theta = 60^\circ$ to the horizontal for a distance $x = 3\ m$. The magnitude of the force is $|\vec{F}| = 3\ N$ and the mass of the cart is $m = 5\ kg$. Assume the cart rolls with no effect due to friction. What is the work done by the force?



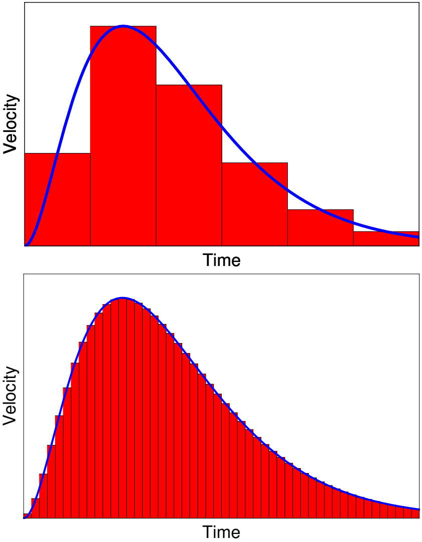
Integrating the Velocity 4



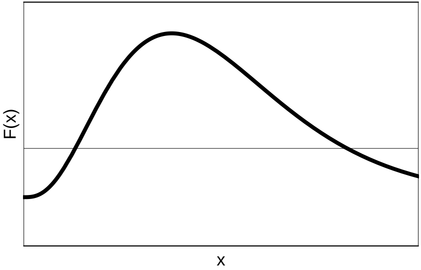
Integrating the Velocity 5

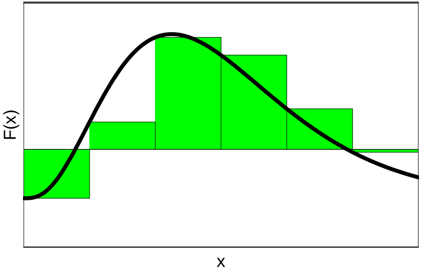


Integrating the Velocity

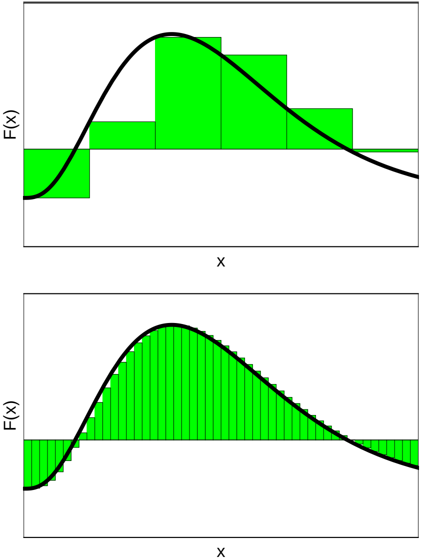


Work and Variable Forces 7




F(x)
x

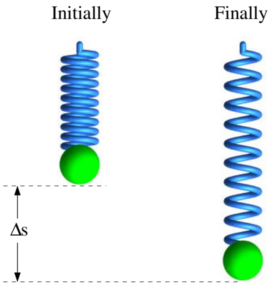
Work and Variable Forces

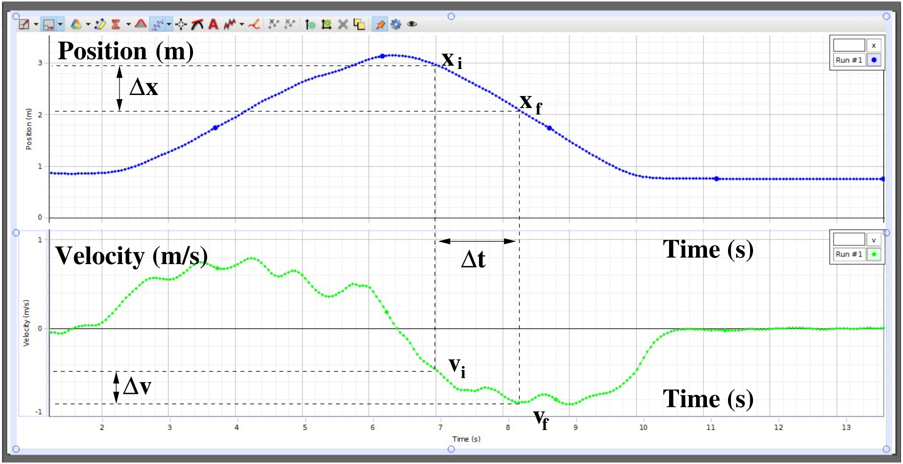


A spring, when stretched, exerts a restoring force that pulls the spring back to its equilibrium position.

$$\vec{F}_s = -k\vec{s}$$

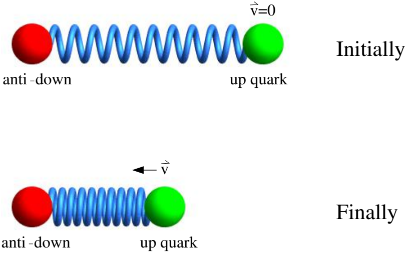
The vector $\vec{s}$ is the displacement of the end of the spring from its equilibrium position. A one-dimensional force $F_1 = 5\ N$ is applied to a spring stretching it from its relaxed, equilibrium state a distance of $|\vec{s}_1| = s_1 = 0.12\ m$. Then, an additional force $F_2 = 2\ N$ is added and the spring stretches another $\Delta s = 0.05\ m$. What is the work done by the spring for this last part? The spring constant is $k = 42\ N/m$.




Position (m)
x_i
Δx
x_f
Velocity (m/s)
Δt
Time (s)
v_i
Δv
v_f
Time (s)
Run #1
Time (s)

Quarks on Springs

Two quarks, an up and an anti-down are bound together (much like atoms bind together to make molecules) to form an object known as a pi meson or pion (π^+). The force between the quarks can be modeled as a spring force to explain their confinement in the pion. If the spring with the up quark attached is stretched a distance s from equilibrium and released from rest, then what is the kinetic energy and speed of the up quark when the spring passes through its equilibrium point and becomes relaxed in terms of the spring constant k and the quark mass m_q? Treat the position of the anti-down quark as fixed.

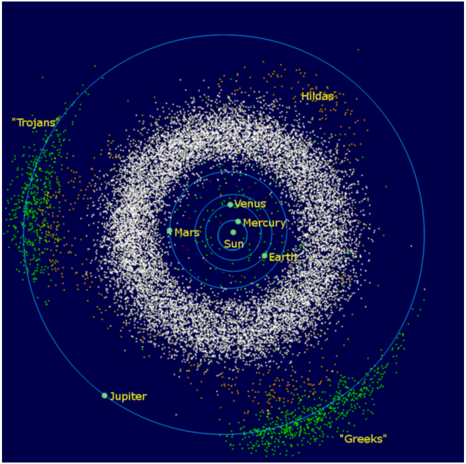


FERMIONS matter constituents spin = 1/2, 3/2, 5/2, ...

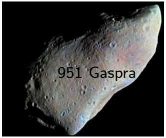
Leptons spin =1/2			Quarks spin =1/2		
Flavor	Mass GeV/c^2	Electric charge	Flavor	Approx. Mass GeV/c^2	Electric charge
ν_L lightest neutrino*	$(0-2)\times10^{-9}$	0	**u** up	0.002	2/3
e electron	0.000511	–1	**d** down	0.005	–1/3
ν_M middle neutrino*	$(0.009-2)\times10^{-9}$	0	**c** charm	1.3	2/3
μ muon	0.106	–1	**s** strange	0.1	–1/3
ν_H heaviest neutrino*	$(0.05-2)\times10^{-9}$	0	**t** top	173	2/3
τ tau	1.777	–1	**b** bottom	4.2	–1/3

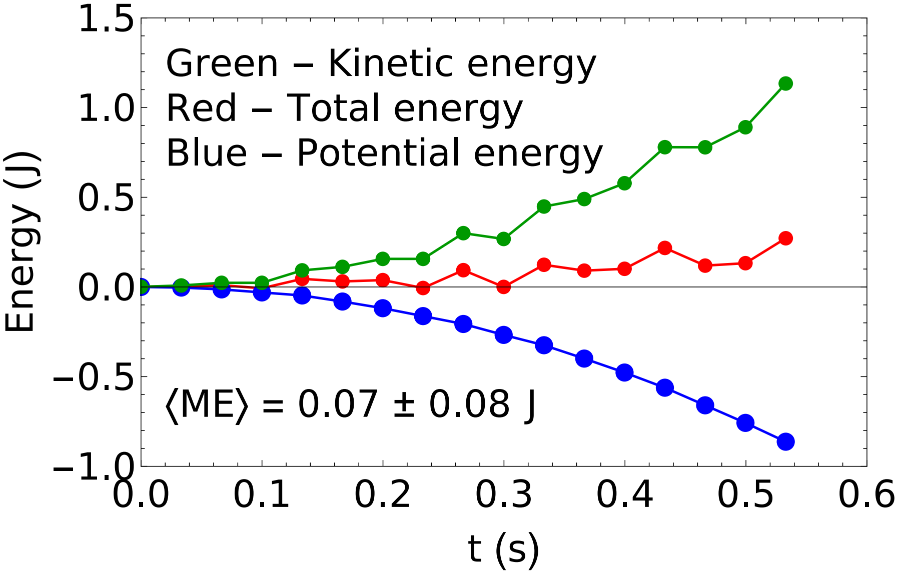
The asteroid belt is a region of our Solar System occupied by many large rocks and is located between the orbits of Mars and Jupiter. Its center is about $r_A = 4.0 \times 10^{11}\ m$ from the Sun. Consider an asteroid with $v_i = 0\ m/s$ from this region that 'falls' down to the orbit of Earth ($r_E = 1.5 \times 10^{11}\ M$). What is its speed when it reaches r_E? Some useful numbers are below. The asteroid mass is typical for asteroids that cross the Earth's orbit.

Solar mass	$1.99 \times 10^{30}\ kg$
Earth mass	$5.98 \times 10^{24}\ kg$
Asteroid mass	$3.4 \times 10^{14}\ kg$



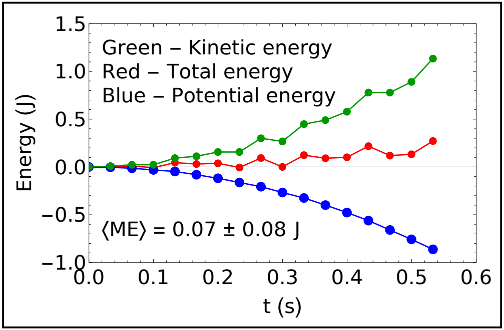
First image of an asteroid from a spacecraft (Galileo, 1991).





Green – Kinetic energy
Red – Total energy
Blue – Potential energy
⟨ME⟩ = 0.07 ± 0.08 J
Energy (J)
t (s)
1.5
1.0
0.5
0.0
−0.5
−1.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6

‘Proof’ of Mechanical Energy Conservation



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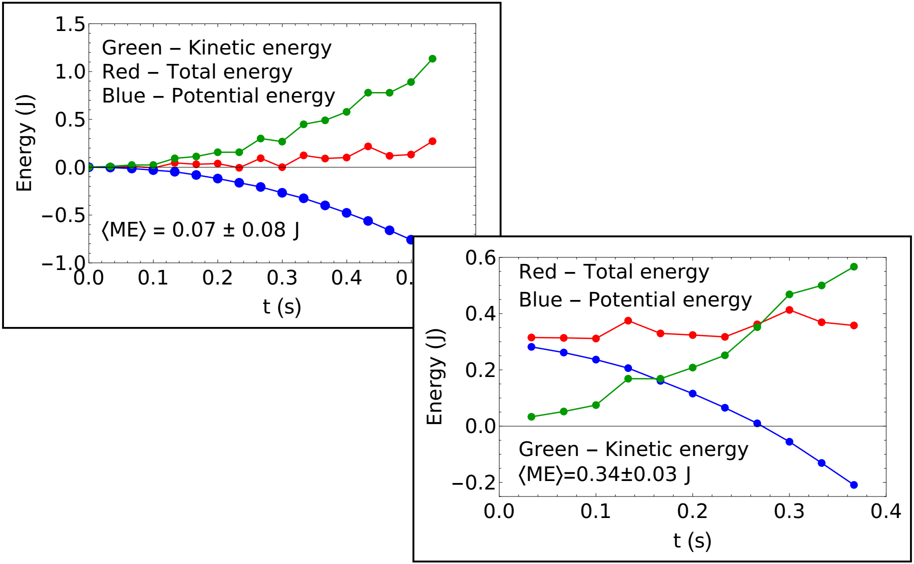

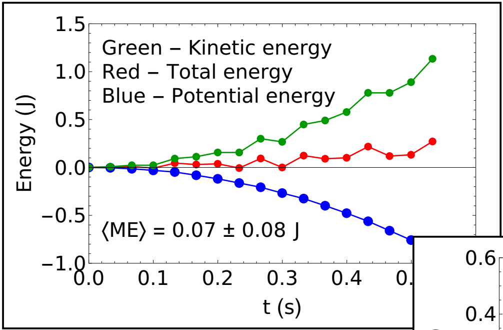

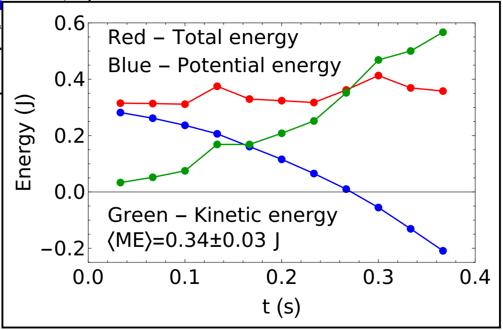

Which one is better?

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Hints for ‘Work and Kinetic Energy’ 19

1. Work done by a force - force and displacement are in the same direction.
2. Work done against/on a force - force and displacement are in opposite directions.