

- The periodic chart orders the chemical elements according to their properties.
- It provides clues to the underlying atomic structure.
- The 'fundamental particles' of the periodic chart are the atoms/elements themselves.
- What are the atoms/elements made of?

Periodic Table of the Elements

1	2																	18	19	20															
H	He																	Ar	K	Ca															
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20																		
Li	Be	B	C	N	O	F	Ne	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr										
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47									
Na	Mg	Al	Si	P	S	Cl	Ar	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr										
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74									
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	
Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn				
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og				

Legend: Alkali Metals, Alkaline Earths, Transition Metals, Lanthanides, Actinides, Noble Gases

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Cs	Ba			Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn									
Fr	Ra			Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og									
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu											
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr											

Legend: Alkali Metals, Alkaline Earths, Transition Metals, Lanthanides, Actinides, Halogens, Noble Gases, Metalloids, Nonmetals, Solids, Liquids, Gases, Radioactive

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																		Lanthanide Series									
																		Actinide Series									

- The periodic chart orders the chemical elements according to their properties.
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- What are the atoms/elements made of? Protons and neutrons
- What are the protons and neutrons made of? Quarks and gluons

Periodic Table of the Elements

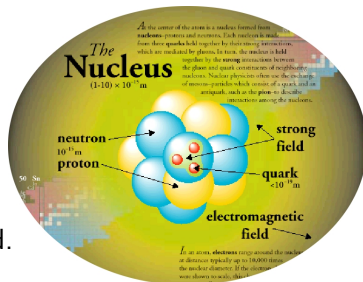
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- The Universe is made of quarks and leptons and the force carriers.

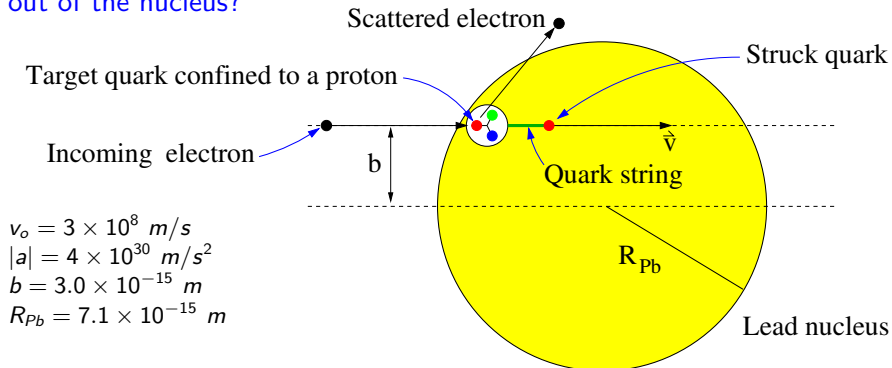
BOSONS			force carriers		
Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W^-	80.39	-1			
W^+ W bosons	80.39	+1			
Z^0 Z boson	91.188	0			

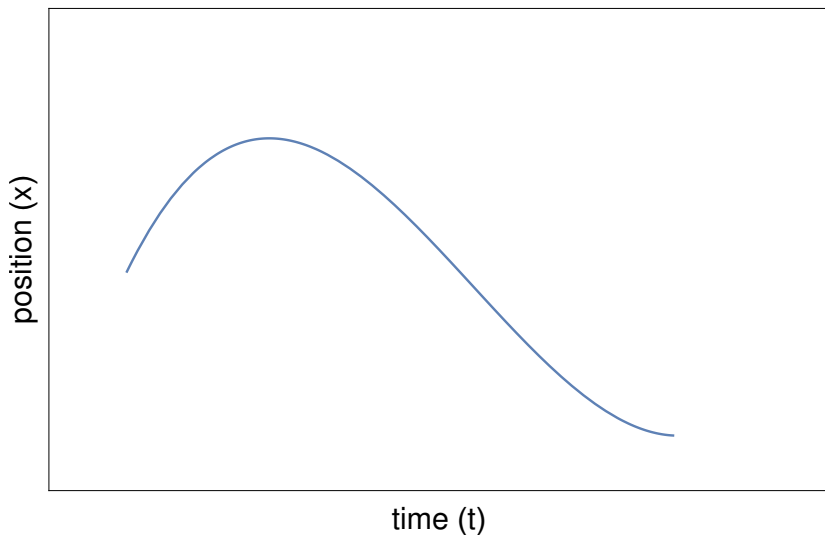
- The atomic nucleus is made of protons and neutrons bound by the strong force.
- The quarks are confined inside the protons and neutrons.
- Protons and neutrons are NOT confined.

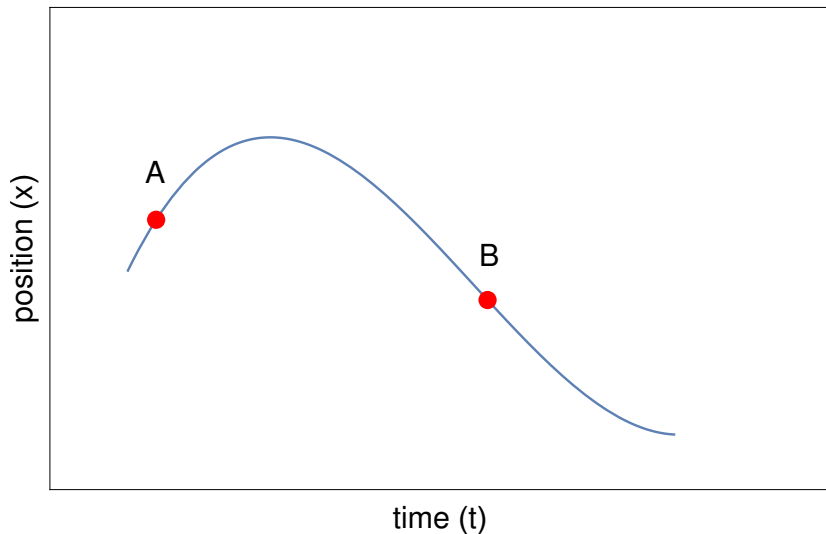
FERMIONS			matter constituents		
Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_L lightest neutrino*	$(0-0.13) \times 10^{-9}$	0	u up	0.002	2/3
e electron	0.000511	-1	d down	0.005	-1/3
ν_M middle neutrino*	$(0.009-0.13) \times 10^{-9}$	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_H heaviest neutrino*	$(0.04-0.14) \times 10^{-9}$	0	t top	173	2/3
τ tau	1.777	-1	b bottom	4.2	-1/3

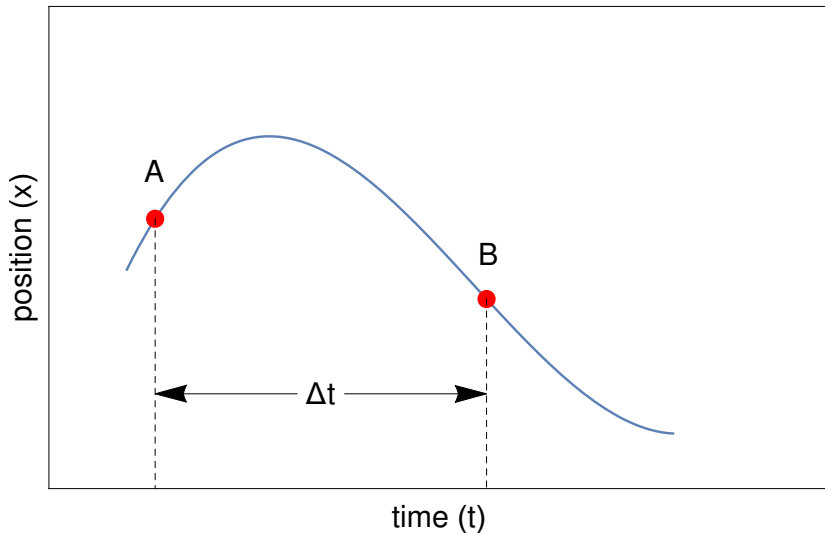


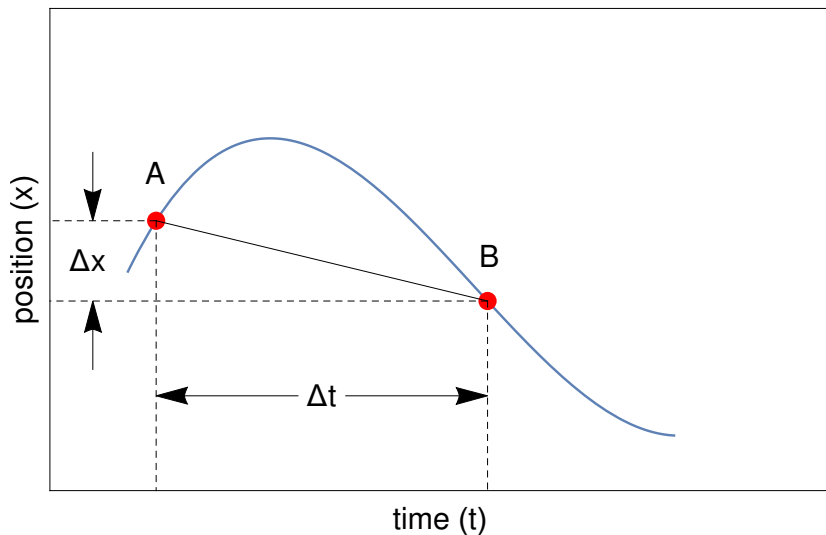
Despite quark confinement there is a way to get them out of the proton or neutron. Hit a quark hard enough with something small like an electron and if it is immersed in nuclear matter, the tug of the nearby protons and neutrons cancels some of the forces on the struck quark. We'll model this struck quark as a particle moving through the nucleus bound to its original partners by a string that exerts a constant force. **Does the quark make it out of the nucleus?**

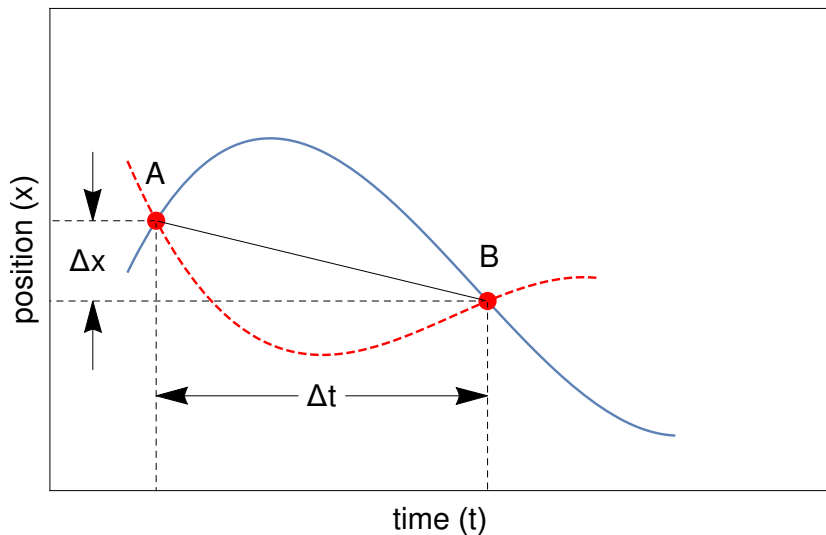


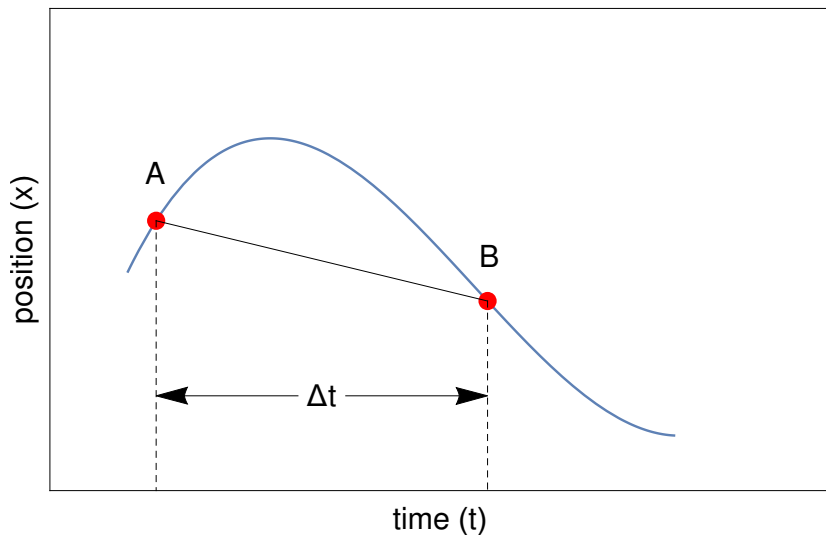


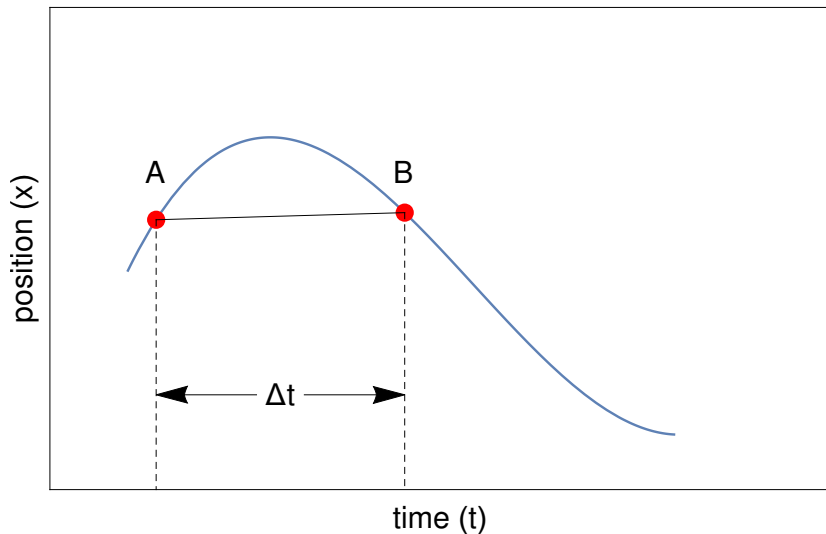


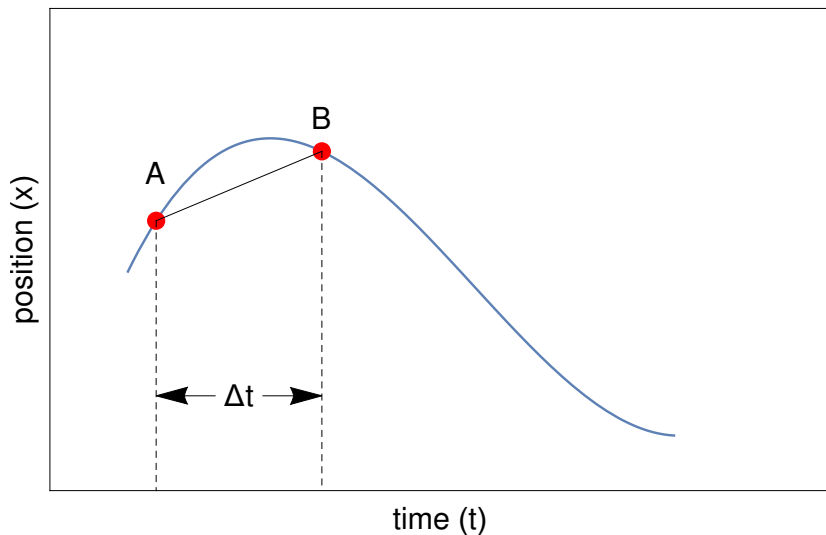


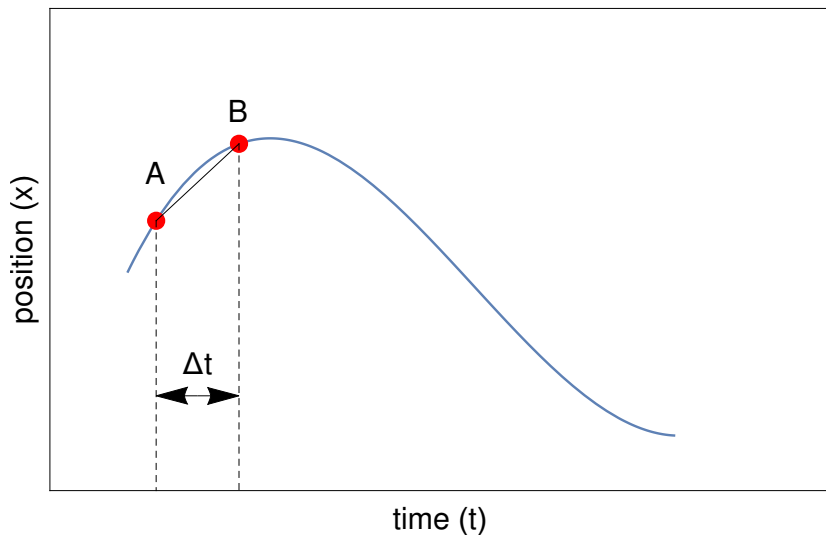


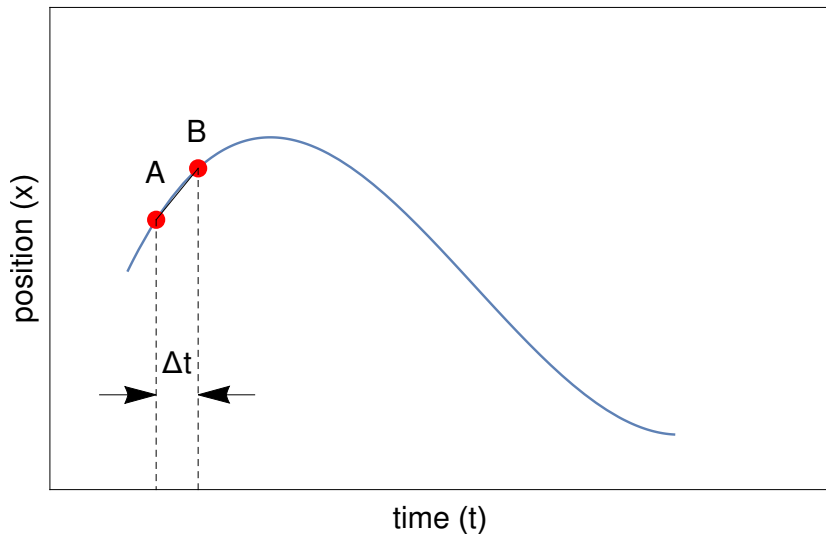


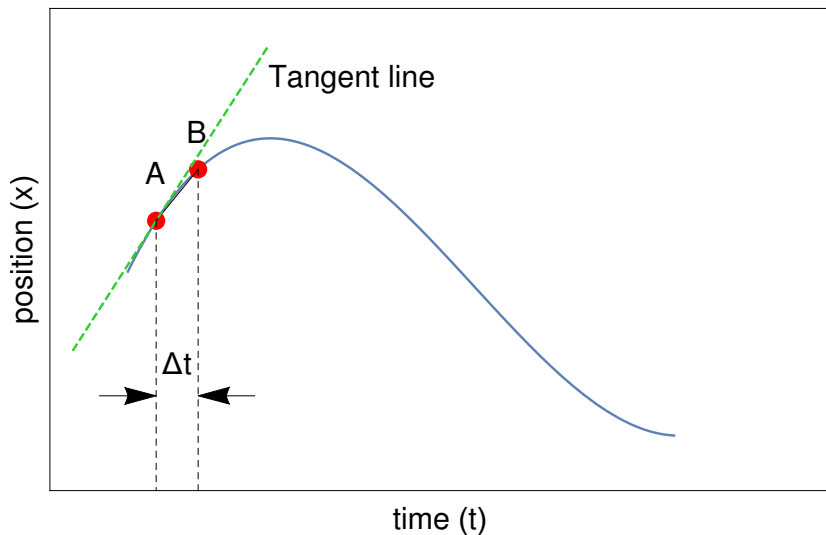


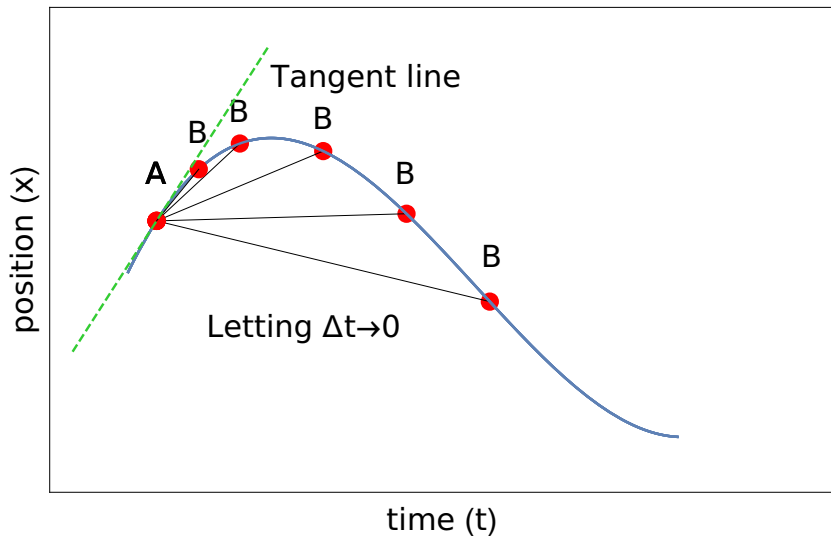










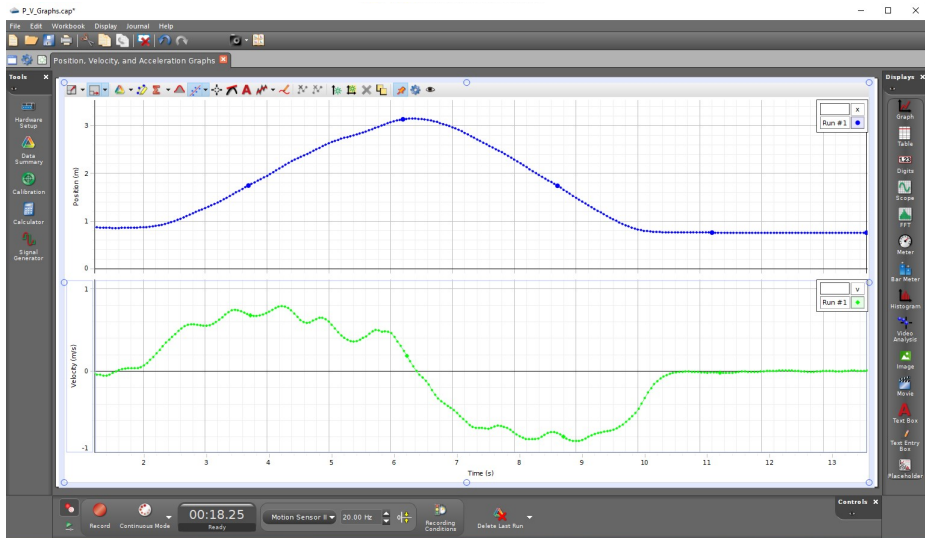


An elevator in the world's tallest building, the Burj Dubai in Dubai, United Arab Emirates, is moving and its vertical position is described by the following equation

$$x(t) = A + Bt + Ct^2$$

where $A = 5.0 \text{ m}$, $B = 2.1 \text{ m/s}$, and $C = -4.9 \text{ m/s}^2$. What is the instantaneous velocity at any time t ? What is the average velocity between two times $t_0 = 0.0 \text{ s}$ and $t_1 = 1.0 \text{ s}$?





The starship Enterprise has lost power and is plunging straight into the heart of a black hole. Its velocity as a function of time is described by

$$v(t) = F + Gt$$

where $F = 2.0 \times 10^7 \text{ m/s}$ and $G = 9.0 \times 10^{10} \text{ m/s}^2$.

What is the instantaneous acceleration?

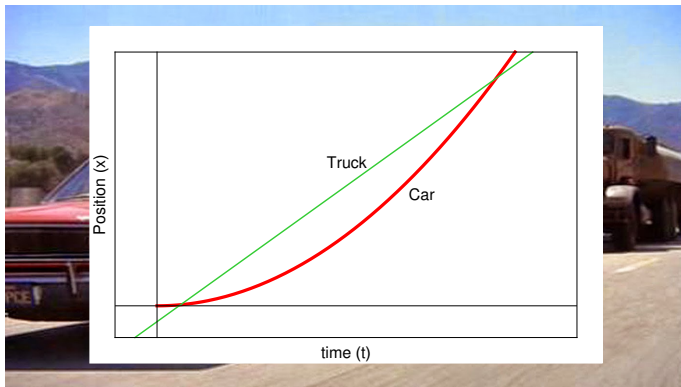
Do the velocity and acceleration versus time plots make sense?



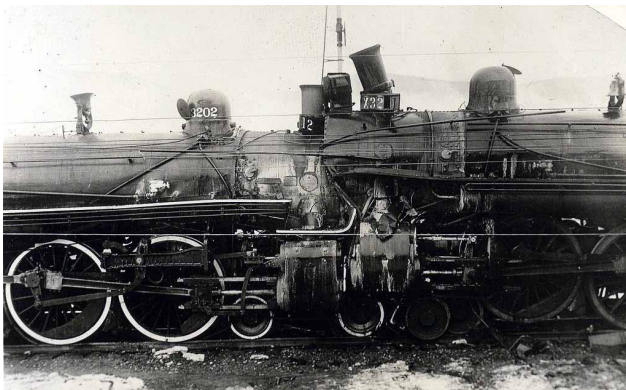
At the instant a traffic light turns green, a 'car' starts with a constant acceleration $a = 2.2 \text{ m/s}^2$. At the same instant a truck is 5.0 m behind the car and traveling with a constant speed $v_t = 9.5 \text{ m/s}$. How far does the car travel before overtaking the truck? What do the position versus time plots look like for the car and the truck?



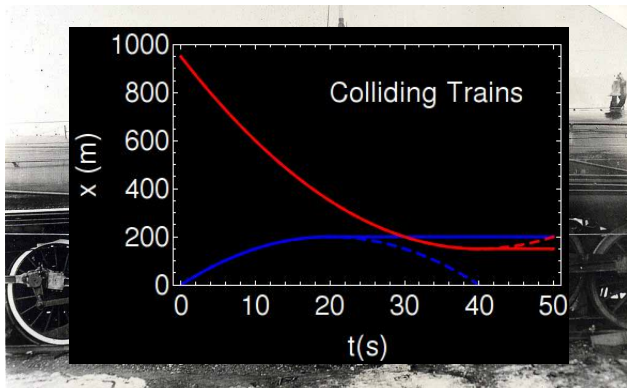
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Two trains, one traveling at 20 m/s and the other at 40 m/s , are headed toward one another along a straight, level track. When they are 950 m apart, each engineer sees the other's train and instantly applies the brakes. The slow-moving train stops. The brakes decelerate each train at a rate of 1.0 m/s^2 . Is there a collision? If so, how long after the brakes are applied?



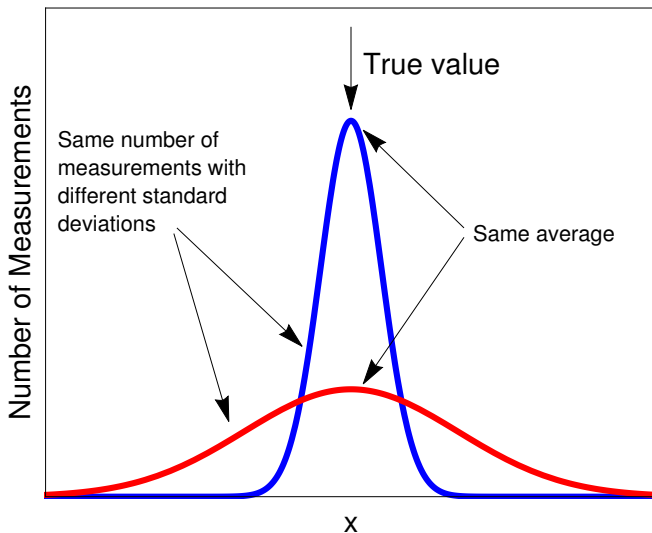
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A window washer named Chris Sagger is reported to have fallen (assume starting from rest) 67 meters from a building where he was working, landed on a car, and lived. Suppose the roof of the car was compressed 1.45 m. Ignoring air resistance what is his speed just before hitting the car? Treating his acceleration as constant, how long did it take him to come to a stop after he made contact with the box? What was his acceleration?



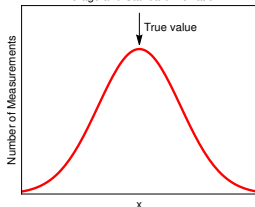
Average and Standard Deviation





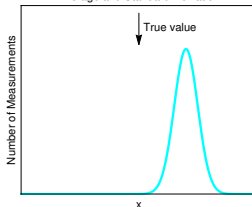
Not precise.

Average and Standard Deviation



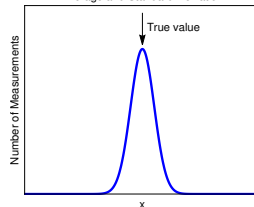
Precise, but not accurate.

Average and Standard Deviation

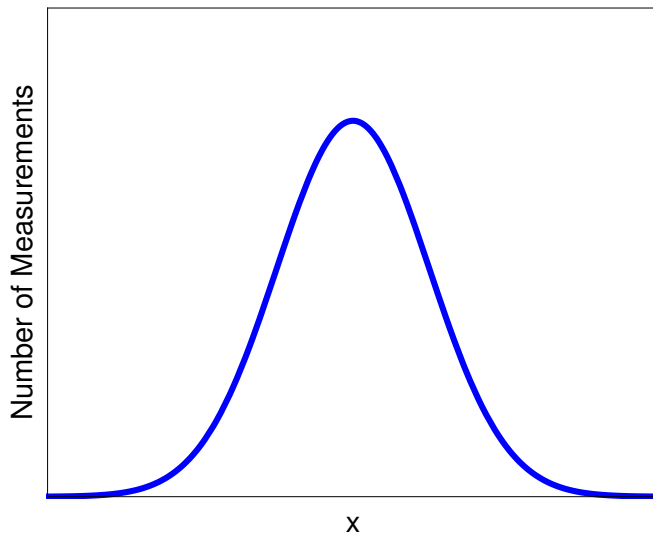


Precise and accurate.

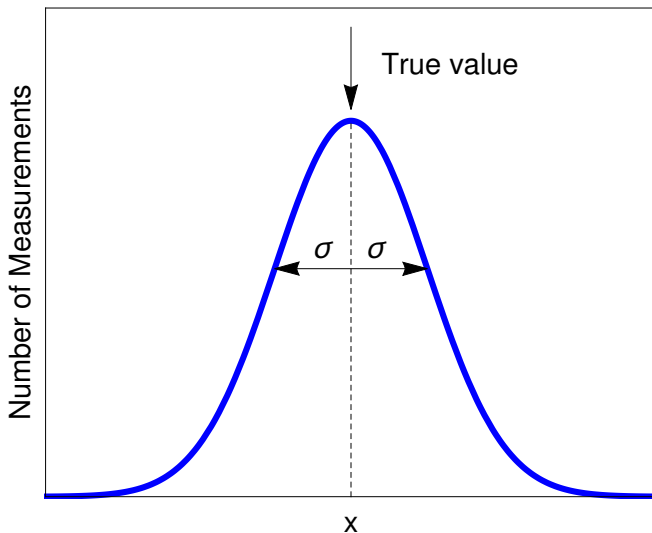
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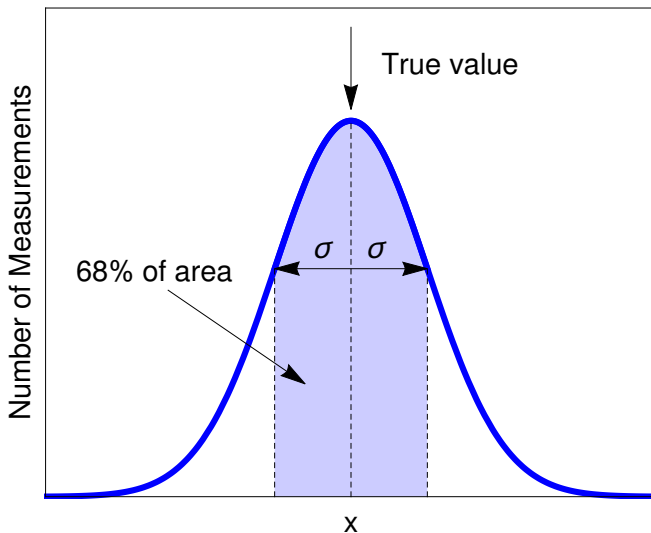
Average and Standard Deviation



Average and Standard Deviation



Average and Standard Deviation



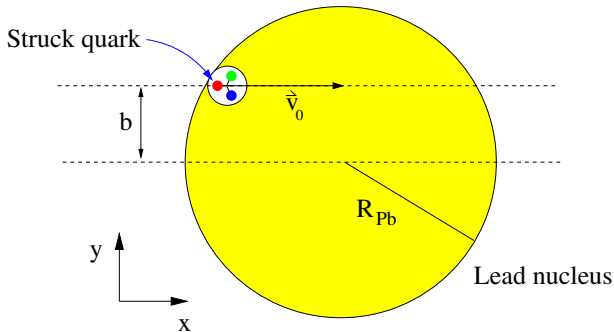
An electron strikes the quark bound inside a proton that is a constituent of a lead nucleus in the configuration shown in the figure. The quark is near the surface of the nucleus. The collision gives the quark an initial velocity \vec{v}_0 and an acceleration \vec{a} as it moves through the nuclear medium. See below for numbers. **Does the quark make it out of the nucleus?**

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$$|a| = 4 \times 10^{30} \text{ m/s}^2$$

$$b = 3.0 \times 10^{-15} \text{ m}$$

$$R_{Pb} = 7.1 \times 10^{-15} \text{ m}$$



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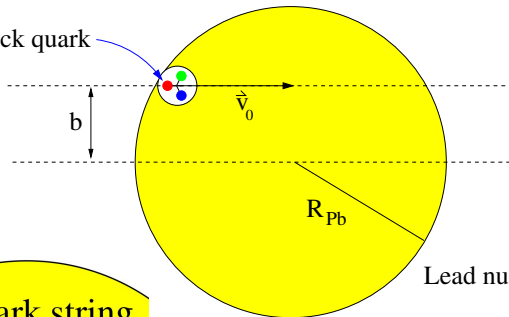
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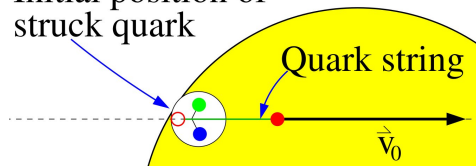
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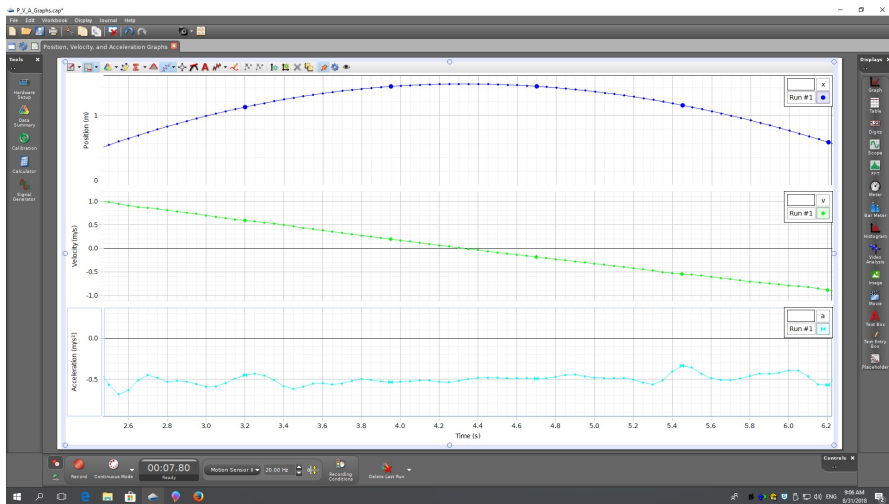
Struck quark



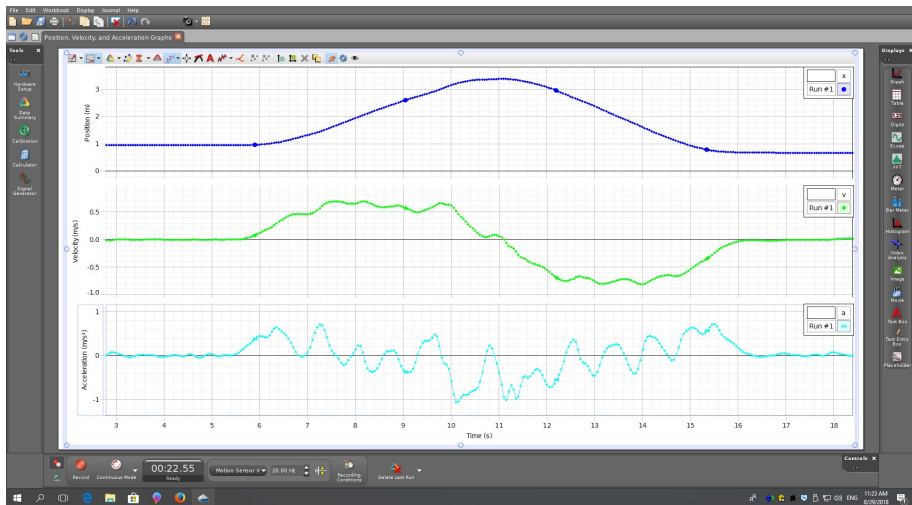
Initial position of struck quark

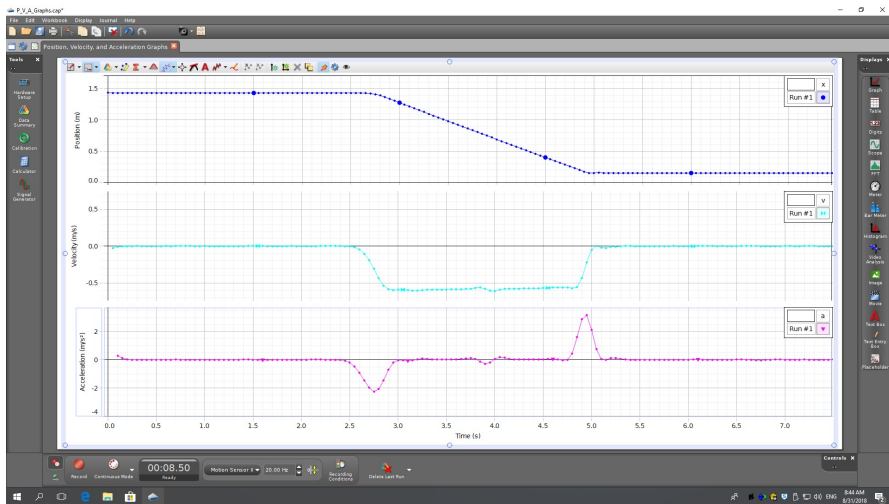
Quark string

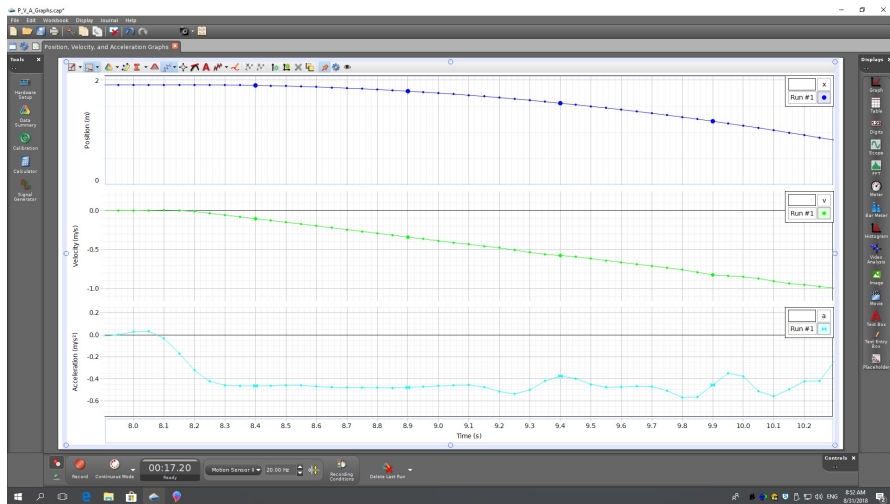


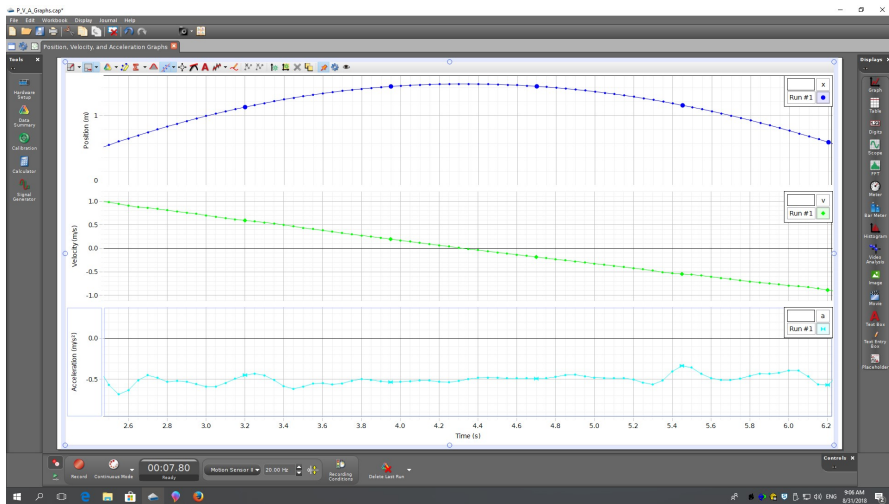


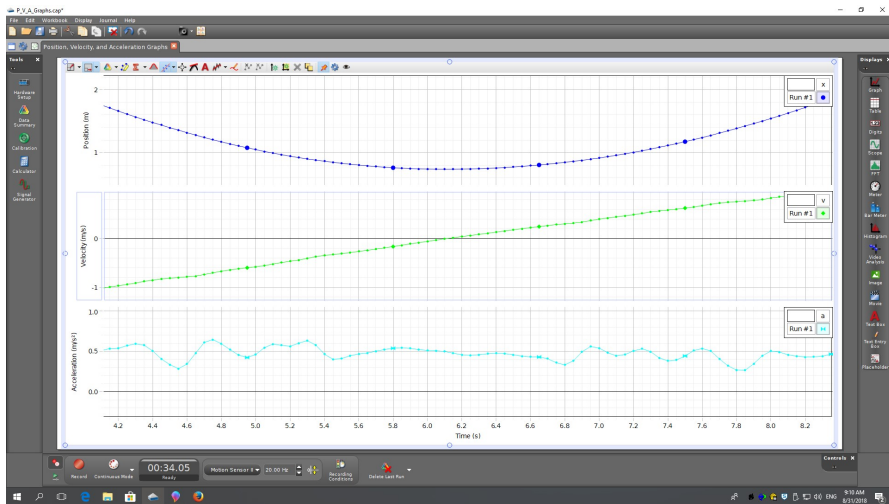


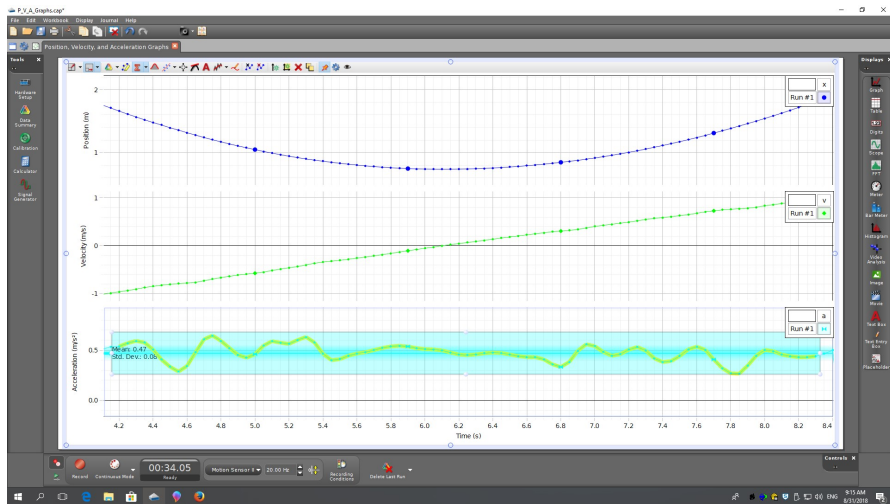












We will be using Zoom for remote access to our Physics 131 lecture/lab meetings. We will meet MWF 1:30-3:30 pm in D115 in Gottwald. See the attendance policy in the syllabus on the course webpage.

- 1 You login to class by clicking on the link in the email I send you before class starts. This is the usual way I get everyone in the class on Zoom. If you have not used Zoom before, you will be asked to download software when you click on the link. Follow the directions and once the software is installed you can connect.
- 2 You will first be placed in a Zoom waiting room. I will admit you to the class when I see you appear on my list. If you are late to class you may not be admitted if I have already begun the lecture.
- 3 When you login you should see a shared screen which will have my lecture slides and a video screen showing the lecture part of the laboratory meeting room.
- 4 Look for a menu called 'View Options' on the right-hand side of the Zoom menu at the top of your screen. Click and check the box by Side-by-Side Mode. You should see the Lecture slides on the left and one or more video screens on the right of your Zoom window.
- 5 If there are multiple video windows on the right-hand-side of your screen then go to the main Zoom menu (you may have to click on the "...") to see the full menu) and select 'Speaker View'. This should be my video screen since I will usually be doing most of the talking.
- 6 Notice that as you move your mouse from one Zoom screen to the adjacent one there is a vertical bar at the border between the two screens. You can click and drag this border to change the sizes of the two screens. Make the video screen big enough that you can read the writing on the board.
- 7 You may find that to see the writing on the board the lectures slides are too small. You can download those slides from the course website. There is a large number in the upper-right corner of each slide so you should be able to follow along on the downloaded slides.
- 8 I may be recording the class (and you can do this on your own computer), but apparently there is no way to control the layout of the recorded session. Typically, the video screen is small and the shared screen is large. You may not be able to read the writing on the board in the video screen. This means you need to take notes during the lecture part of class as you would normally.
- 9 You're now ready for class.

- Name:
- How many semesters of physics?
- How many semesters of calculus?
- Preferred personal pronouns?

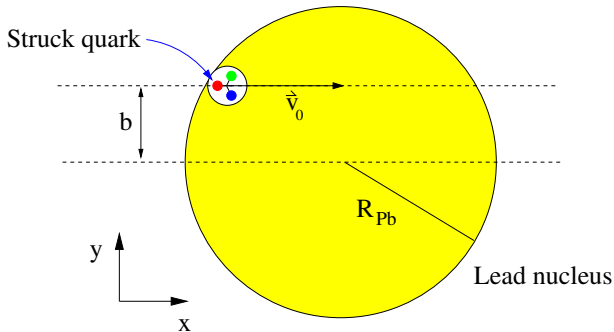
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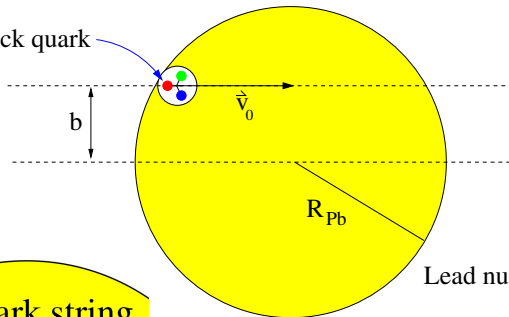
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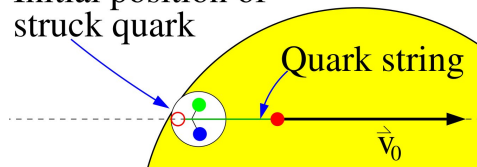
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Struck quark



Initial position of struck quark

Quark string



Does the quark escape?

46

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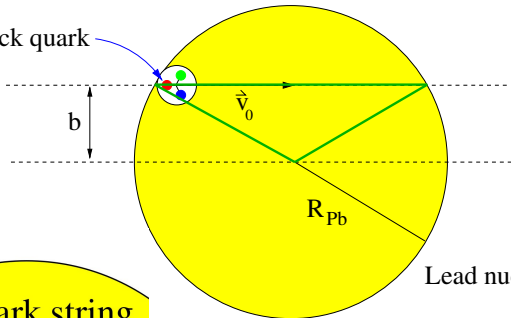
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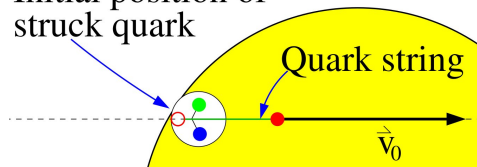
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Does the quark escape?

47

An electron strikes the quark bound inside a proton that is a constituent of a lead nucleus in the configuration shown in the figure. The quark is near the surface of the nucleus. The collision gives the quark an initial velocity \vec{v}_0 and an acceleration \vec{a} as it moves through the nuclear medium. See below for numbers. **Does the quark make it out of the nucleus?**

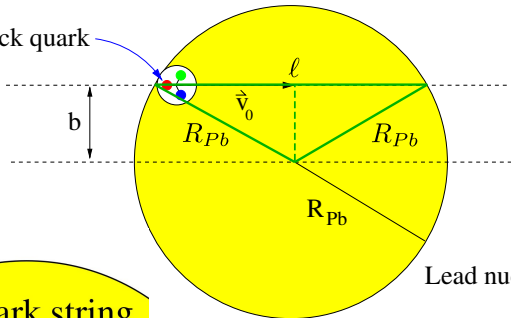
$$v_o = 3 \times 10^8 \text{ m/s}$$

$$|a| = 4 \times 10^{30} \text{ m/s}^2$$

$$b = 3.0 \times 10^{-15} \text{ m}$$

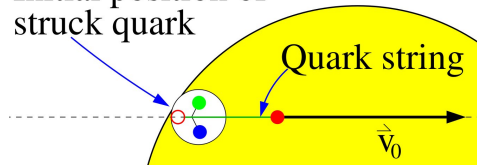
$$R_{Pb} = 7.1 \times 10^{-15} \text{ m}$$

Struck quark



Initial position of struck quark

Quark string



Does the quark escape?

48

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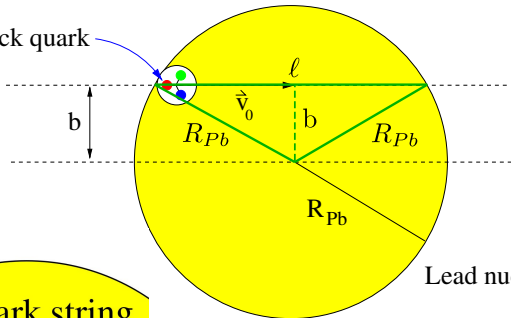
$$v_o = 3 \times 10^8 \text{ m/s}$$

$$|a| = 4 \times 10^{30} \text{ m/s}^2$$

$$b = 3.0 \times 10^{-15} \text{ m}$$

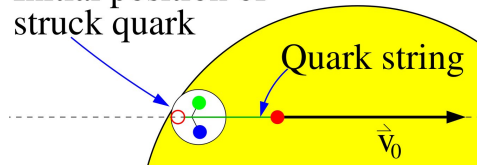
$$R_{Pb} = 7.1 \times 10^{-15} \text{ m}$$

Struck quark



Initial position of struck quark

Quark string



Does the quark escape?

49

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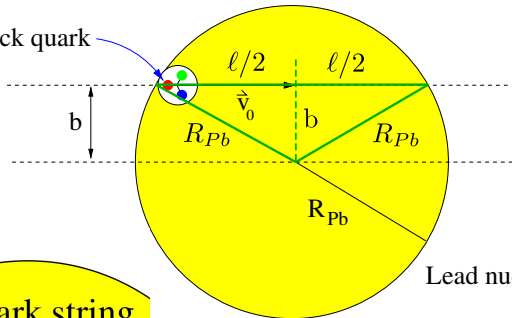
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$$R_{Pb} = 7.1 \times 10^{-15} \text{ m}$$

Struck quark



Initial position of struck quark

Quark string

