



I lære som kvantefysiker

Playful training of anyone
for research



Jacob Sherson
AU ideas Center for Community
Driven Research (CODER)

Gymnasielærerdag
22/1 - 2015



Videnskabelig udfordring 1: flyt atomer

8.0 s

Your Task

This is a scientific challenge. Get the quantum particle to the target and under the red line. And do it quickly - speed is rewarded!

We know that the tutorial games you have completed so far are not sufficient to explain the link to research, but try it anyway...

Leaderboard

1. CODERtester: 99.6216
2. Dr. J: 92.3310
3. norup: 91.5225
4. dynaprog: 90.4520
5. Tilo: 90.4134
6. Azrael90: 90.2505
7. PhilserMachine: 90.1908
8. oldguy: 89.1935
9. gedemagt: 85.9896
- ...

Citizen science



scienceathome.org

Firefox | Jacob Sherson - Outlook Web App | ScienceatHome | Home | http://www.scienc...antumphysics.php

scienceathome.org | brain idea

ScienceatHome | Home | Jacob Sherson - Outlo...

SCIENCE AT HOME ^{BETA}

Game | Community | QWiki | About



Sign in

DO SCIENCE AT HOME

Help solve a real scientific challenge by playing
Our dream is to allow everyone to do real science

FIRST CHALLENGE: PLAY "QUANTUM MOVES"
COMPUTER TO RULE THEM ALL -

PLAY NOW!

Man vs Machine



ONE



GET INVOLVED



3075

#Number of players

Man with Machine

355882

#Number of games played



3522

#Number of badges earned



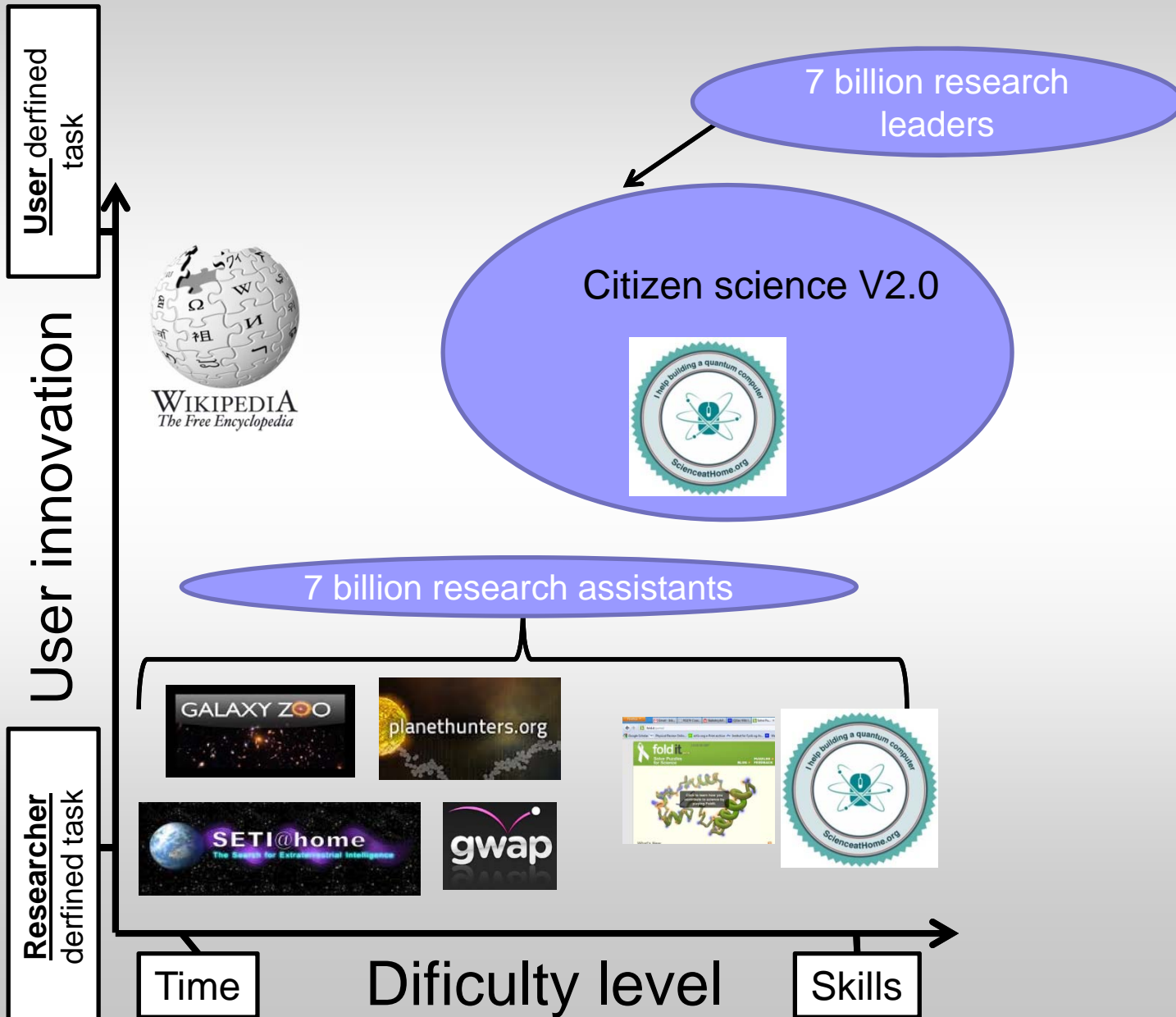
@QuantumMoves



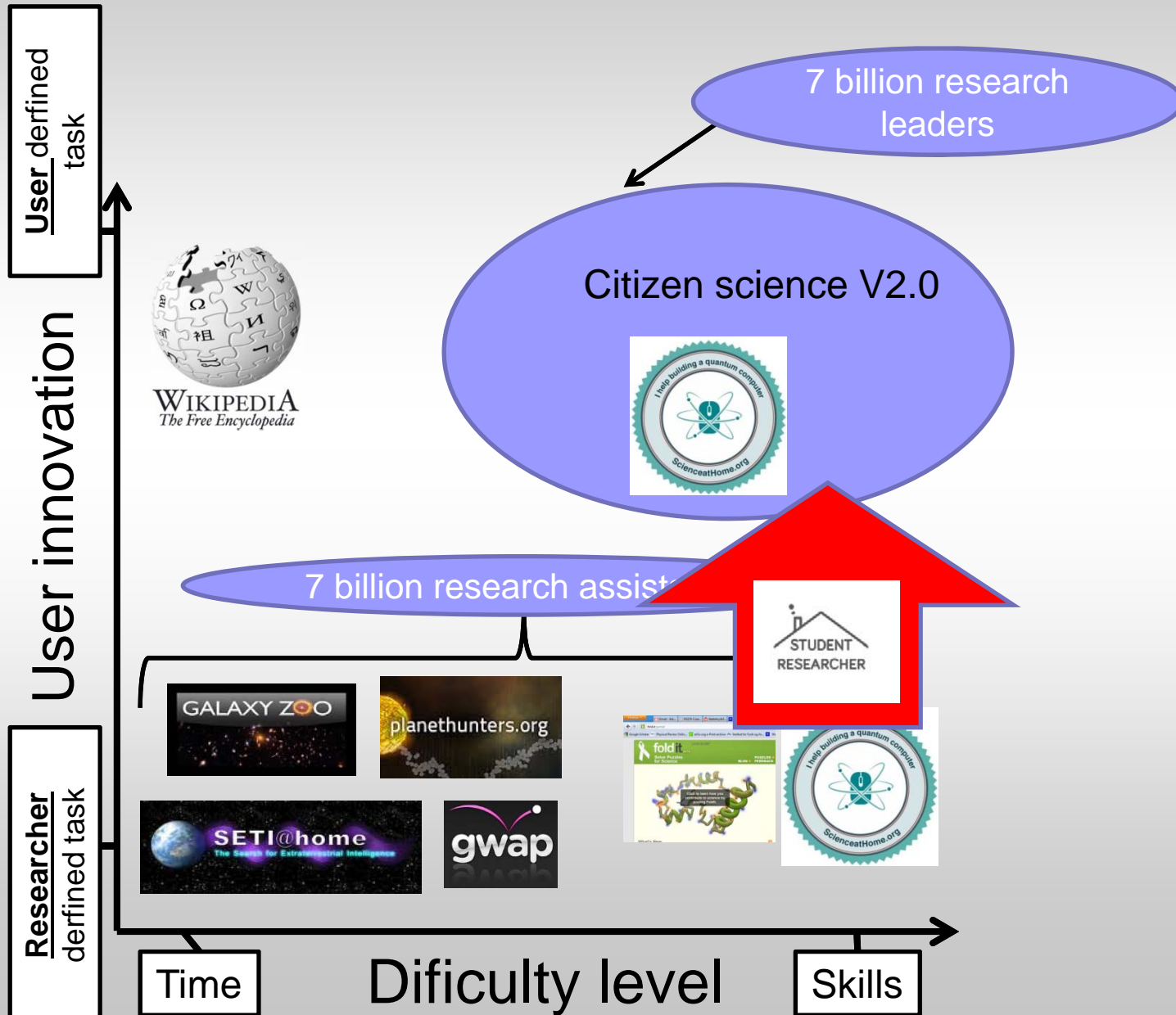
scienceathome.org

COOKIES

Citizen science



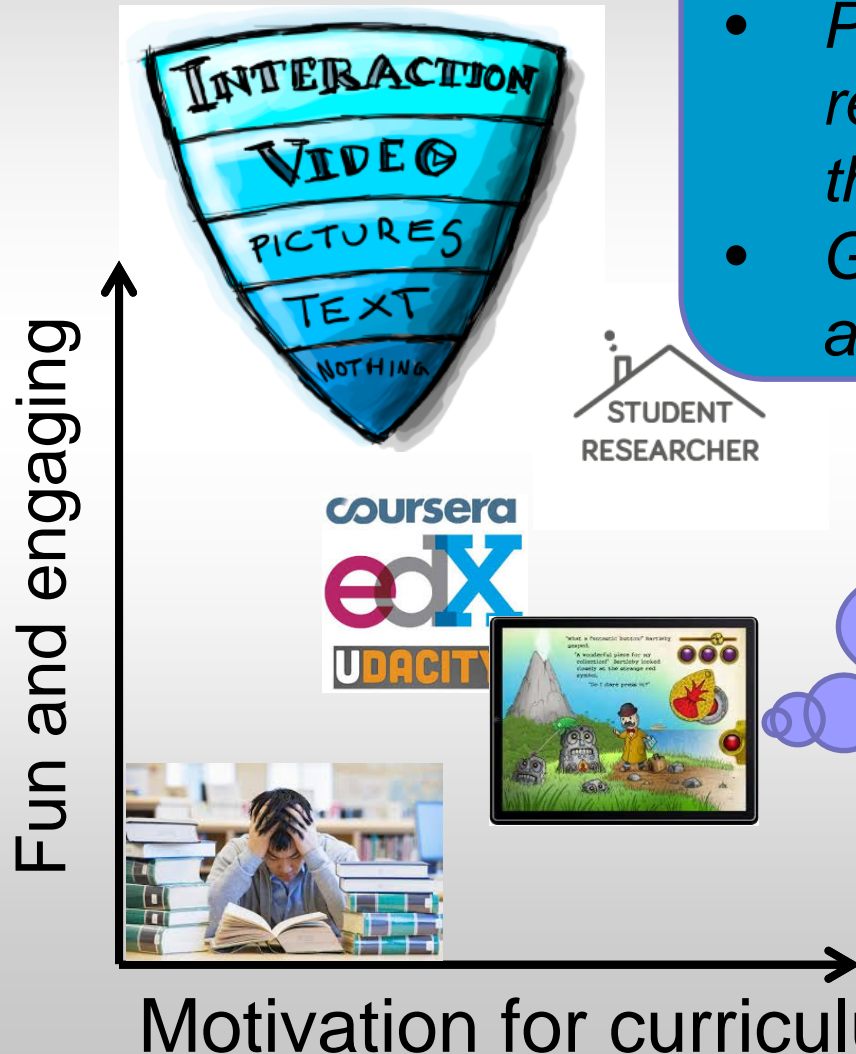
Citizen science



Teaching modes

Main teaching hypotheses:

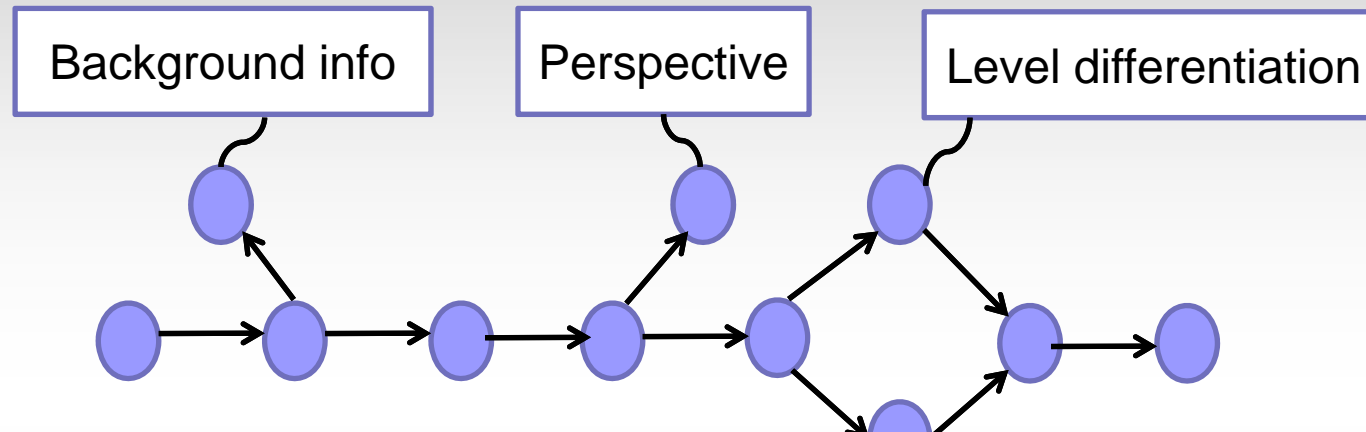
- *Presenting the curriculum in a research relevant context increases the motivation to learn.*
- *Game-based education activates and motivates*



"Most ibooks for school today are simply slightly improved normal books "
High school, physics teacher

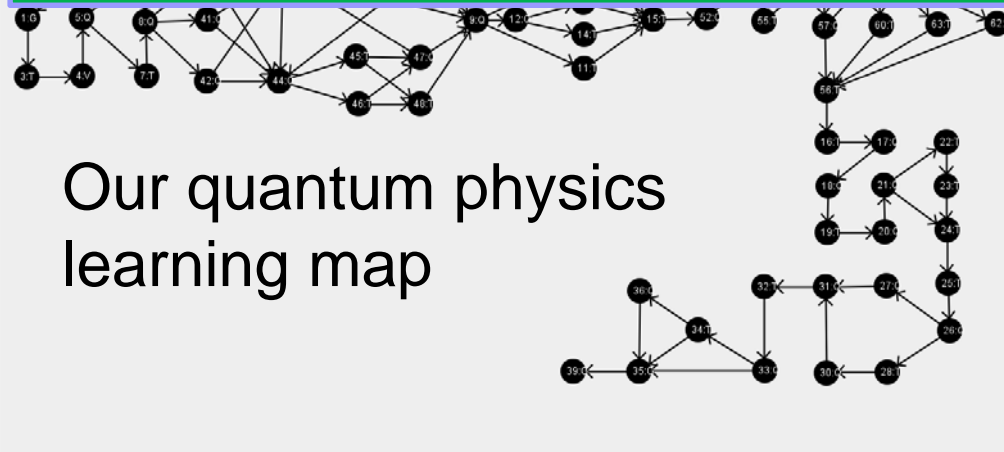
studentResearcher, learning paths

A generic learning map



Personaliseret læring

quo:



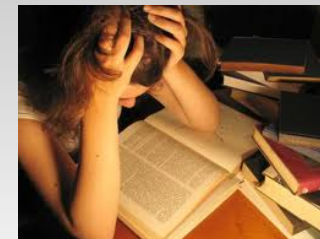
Our quantum physics learning map

- ~80 learning slides
- ~20 games/interactive illustrations
- ~80,000 unique learning trajectories

Hvorfor gamificere uddannelse?



To typer af elever



Mastery:

- Vil blive så dygtig til et emne som overhovedet muligt.
- Læringsprocessen er vigtig
- Intrinsisk motivation
- Engagement
- Villighed til at tage chancer

Performance :

- Ønsker at score højt på eksterne indikatorer for succes
- Karakteren er vigtig
- Extrinsisk motivation
- Eksamensangst
- Modvilje mod at tage chancer

Computer spil

Hvad er så den store forskel mellem typerne?

Deres opfattelse af at fejle!

En læringsproces vs stigmatisering



Spillerne skal iterativt tilføje indhold/strategier ved at fejle gang på gang.

Videnskabelig udfordring 1: flyt atomer

8.0 s

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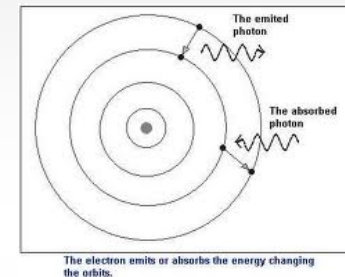
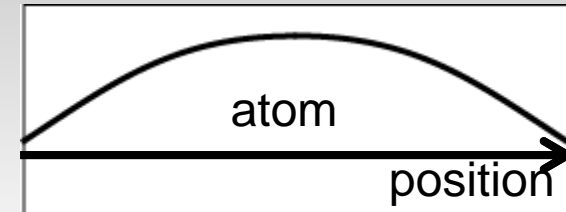
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Leaderboard

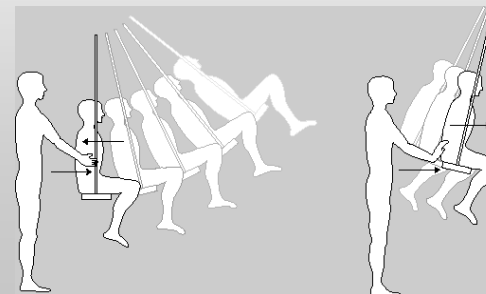
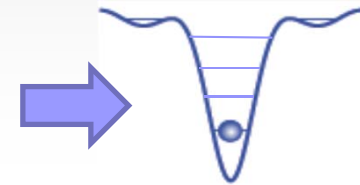
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- ...

Hvad har man brug for at vide?

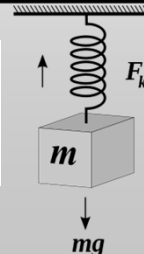
- Hvad er en bølgefunktion
- Hvad er Bohrs specielle tilstande i en pincet af lys (Schr. ligning)
- Hvorfor skvulper et atom når man flytter på det
- Hvordan tager man energi ud af et skvulpende atom



The electron emits or absorbs the energy changing the orbits.

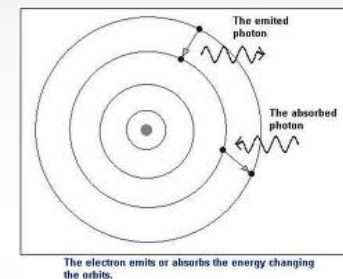
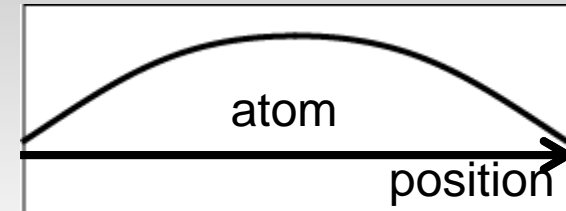


Harmonisk oscillator

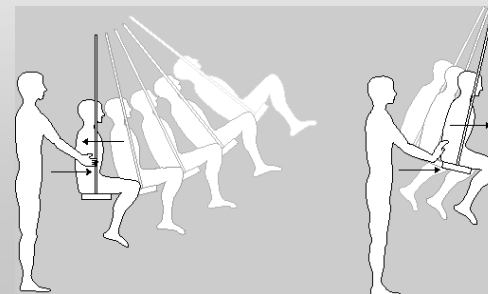
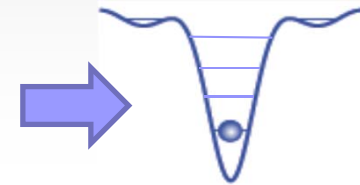


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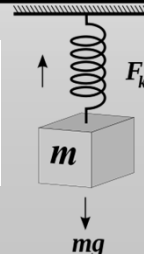
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Harmonisk oscillator



Kvantefysik - målinger

Kvantefysik

The Quantum Computer Game

ABOUT

CHALLENGE

PREVIEW

PEOPLE

EDUCATION

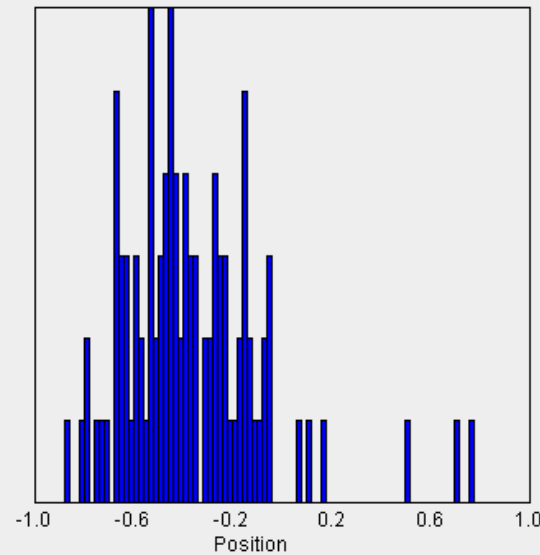
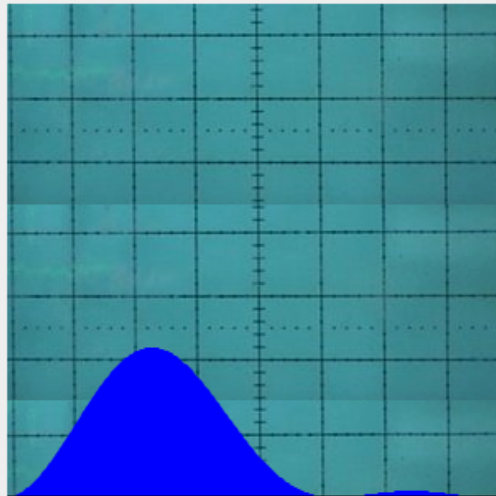
BØLGEFUNKTIONER OG MÅLINGER

/ Education / Aarhus Tech /

LOGIN

Til venstre ser du en bølgefunktion i en boks. Klik på knapperne til højre for at foretage en, 100, eller 1000 målinger i position eller energi.

- [Register profile](#)
- [Existing profile](#)



Position	Energy
1 non-destructive	
1 destructive	
<input type="text" value="100"/>	
10000	
Continue	
reset	

Kvantefysik - målinger

Kvantefysik

The Quantum Computer Game

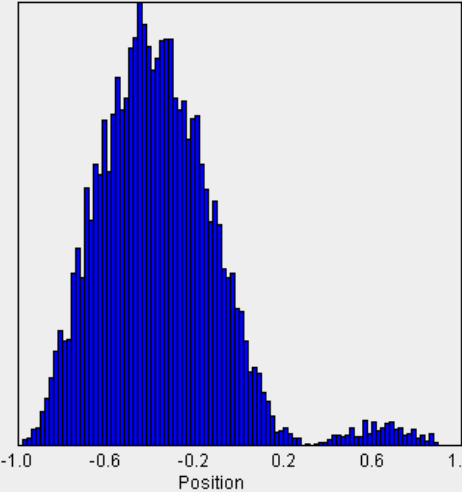
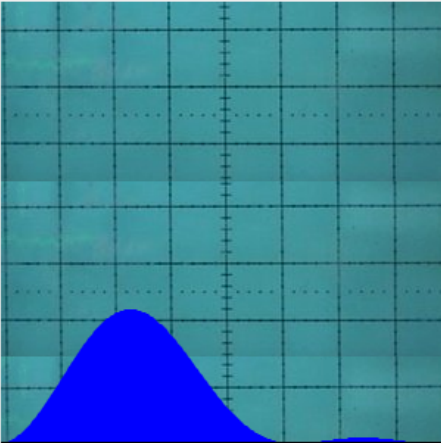
ABOUT CHALLENGE PREVIEW PEOPLE EDUCATION

BØLGEFUNKTIONER OG MÅLINGER

/ Education / Aarhus Tech / LOGIN

Til venstre ser du en bølgefunktion i en boks. Klik på knapperne til højre for at foretage en, 100, eller 1000 målinger i position eller energi.

- [Register profile](#)
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Position Energy

1 non-destructive

1 destructive

100

10000

Continue

reset

Kvantefysik - målinger

Kvantefysik

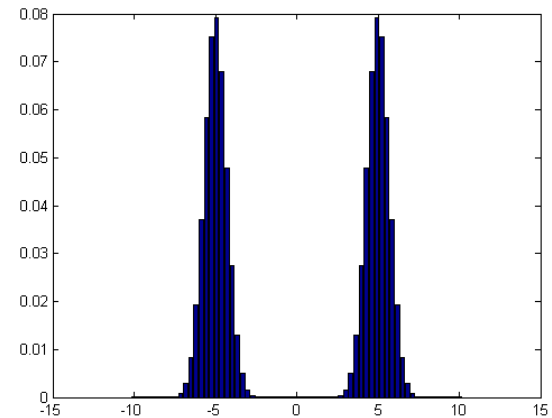
The Quantum Computer Game

Intuitiv forståelse af bølgefunktion

Areal under graf -> fortolkning

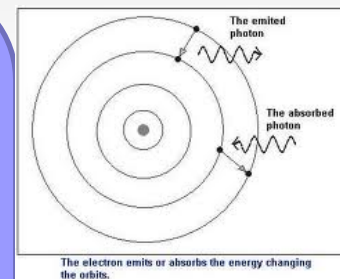
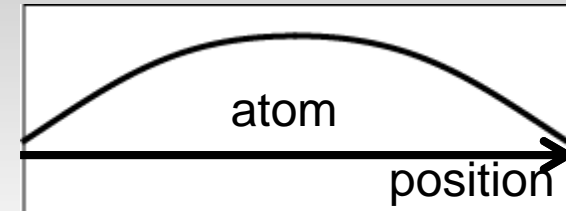
Middelværdi

$$\langle x \rangle = \sum x_i p_i$$

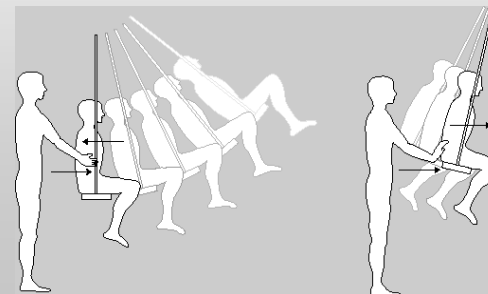
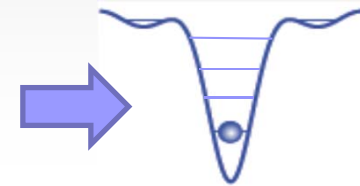


Hvad har man brug for at vide?

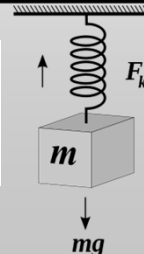
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The electron emits or absorbs the energy changing the orbits.



Harmonisk oscillator



Kvantefysik – stationære tilstande

Kvantefysik

The Quantum Computer Game

ABOUT CHALLENGE PREVIEW PEOPLE EDUCATION

STATIONÆRE TILSTANDE

/ Education / Aarhus Tech /

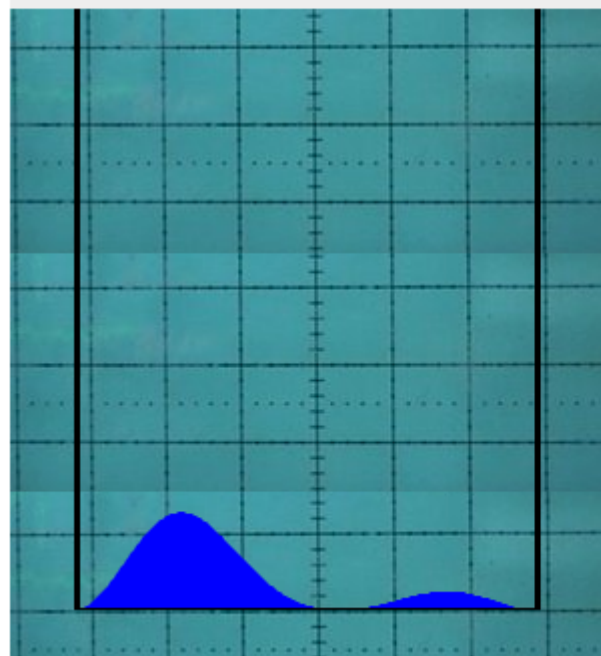
LOGIN

Til venstre ser du en bølgefunktion i et potential. Bølgefunktionen er en sammensætning af stationære tilstande.

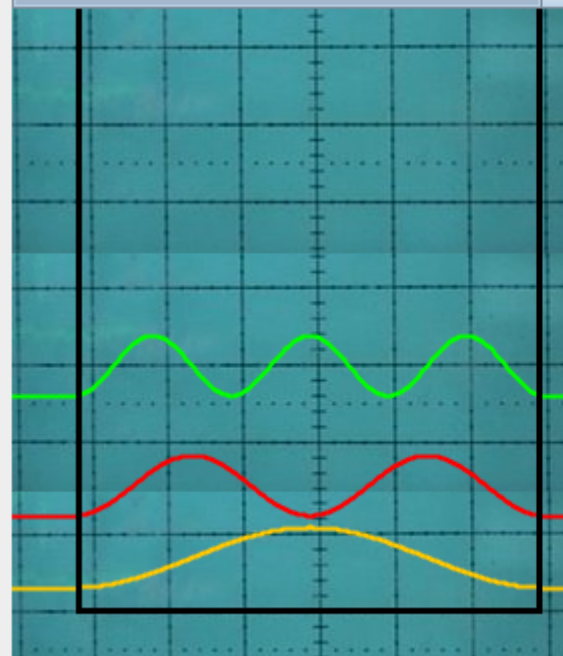
- [Register profile](#)
- [Existing profile](#)

I midten de tre laveste stationære tilstande. Prøv at ændre forholdet mellem de tre stationære tilstande i bølgefunktionen.

Wave function in a potential



Infinite square well



Ground State

100 %

0 %

1st excited State

100 %

0 %

2nd excited State

100 %

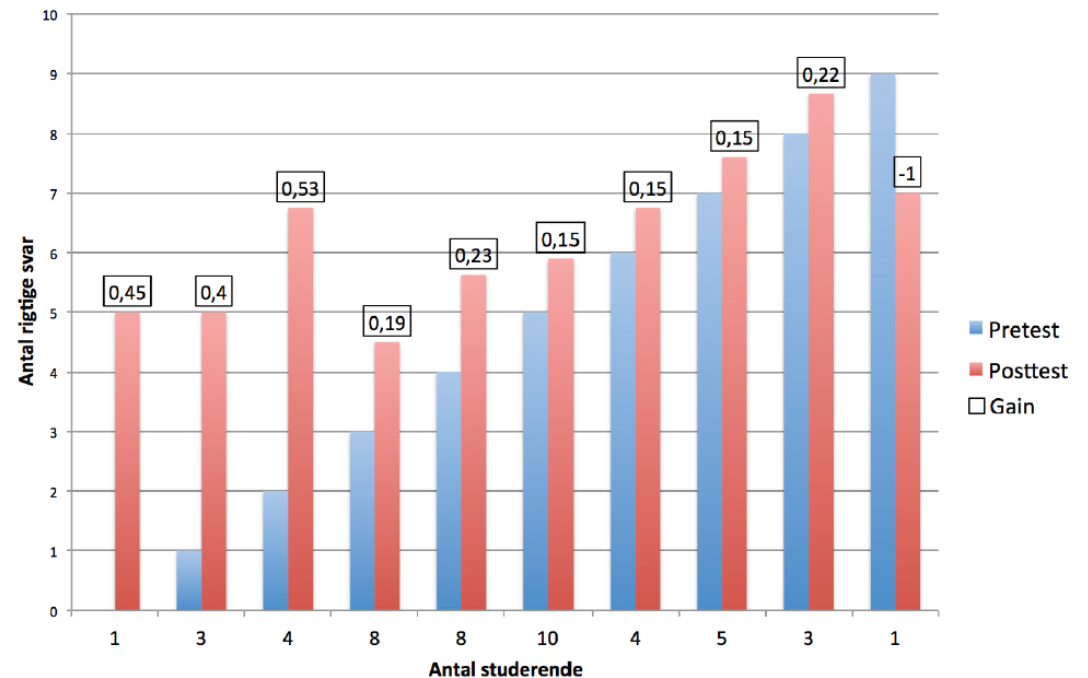
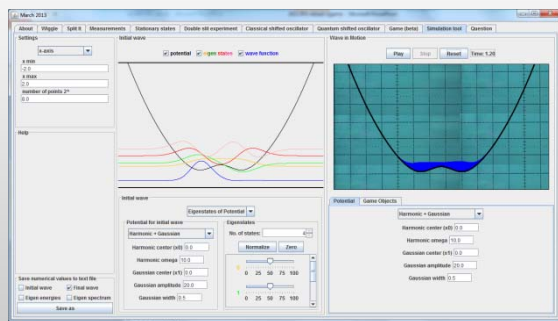
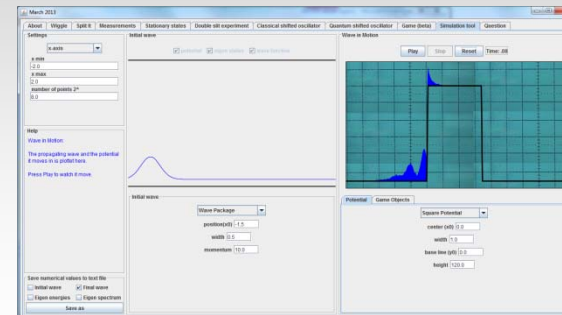
0 %

Et godt eksempel

Gamified quantum mechanics (KM 2nd year course), March 2013

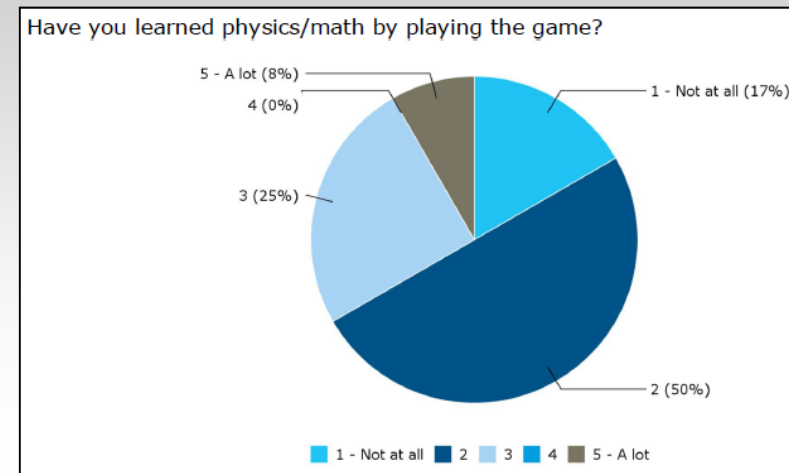
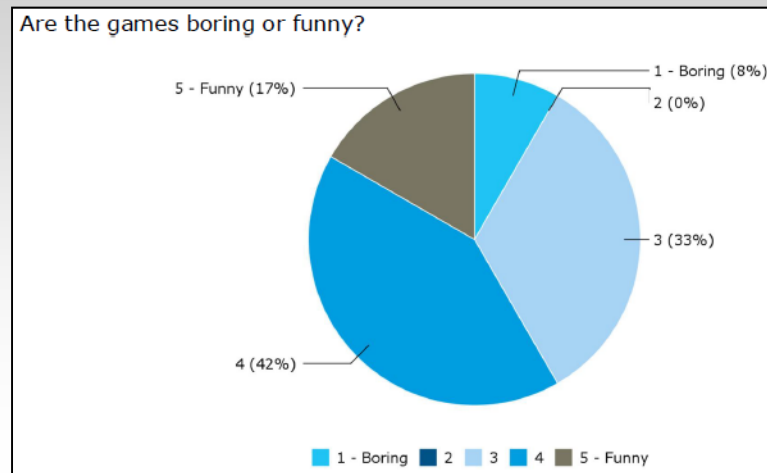
Replacement for theoretical exercises (TØ):

- Graphical exercises illustrating
 - Eigenspectrum of various potentials
 - Time evolution of superpositions of eigen states
 - Wavepacket scattering
 - Double well tunneling
- Pretest + post test demonstrated increase in learning



2 "dårlige" eksempler

Første resultater, Odsherred Feb. 2012



“Især det konkurrencemæssige aspekt er virkelig et scoop. Det er lige som om I udnytter **den mest primale del af mennesket til at udføre videnskab.**”

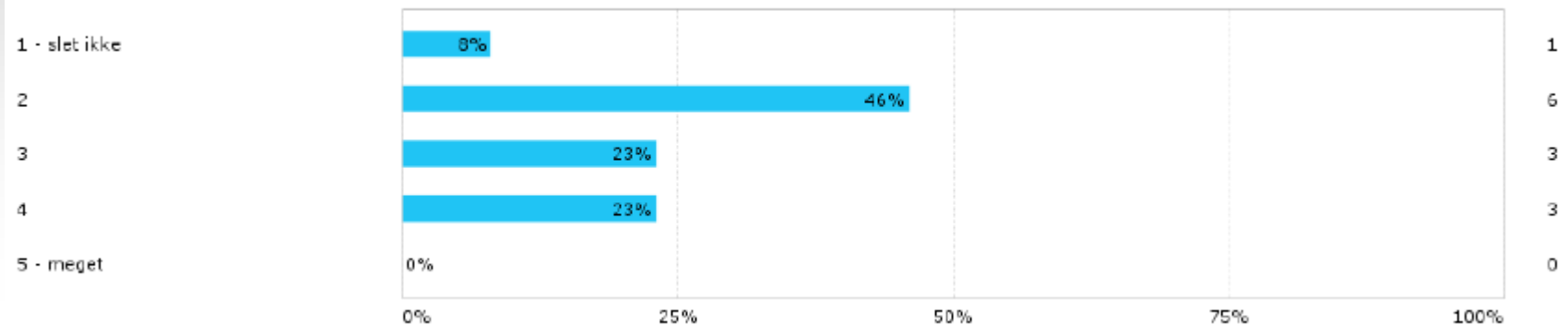
“Kvantefysik er pludselig meget **mere håndgribelig nu**, noget der ikke er et farligt monster du ikke kan forstå. **Det burde være i enhver skole.**”

“I den normale undervisning beregner du det bare, hvorimod du i spillet **får fornemmelsen af virkelig at udføre eksperimentet.**”

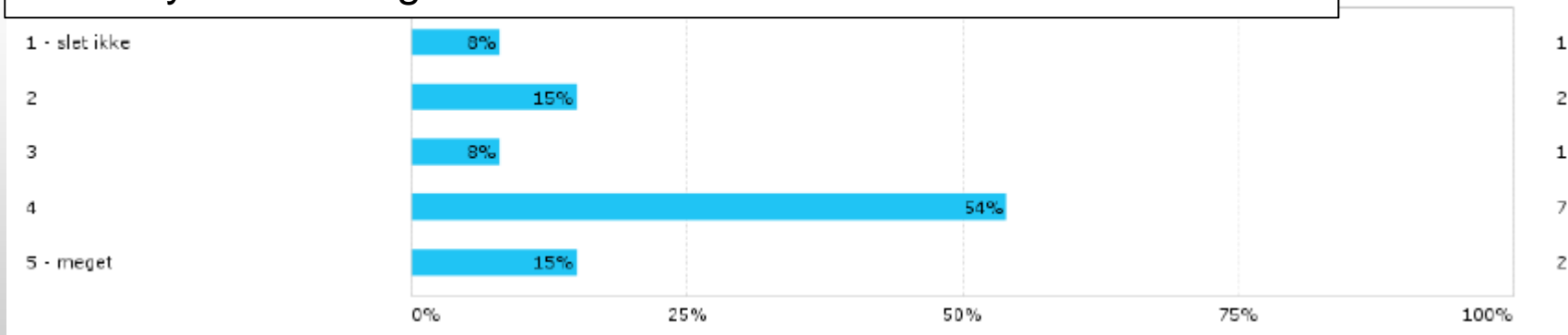
“Jeg synes I har fundet et **super mix af tutorial spil og svære videnskabelige spil.**”

Seneste resultater, ASG Okt. 2012

Har du lært fysik ved spil i undervisningen?



Har forløbet med computerspillet givet dig større indblik i moderne kvantefysikforskning?

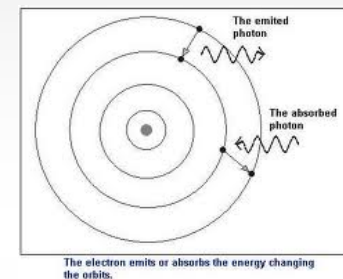
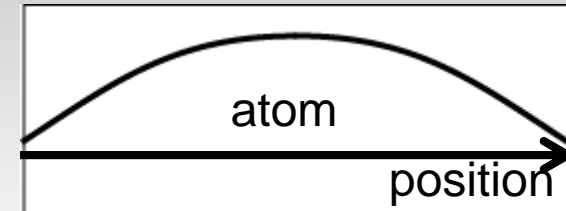


Hvad var forskellen???

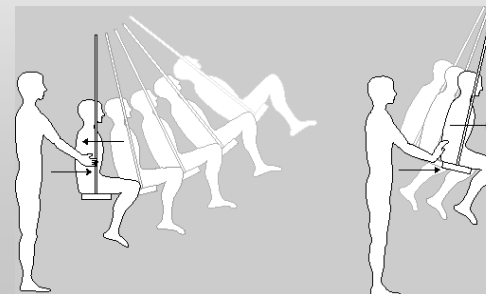
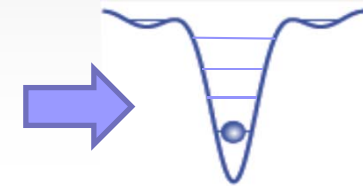
Koblingen til kernepensum

Hvad har man brug for at vide?

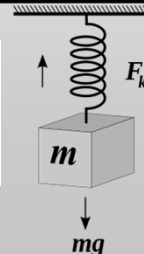
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Harmonisk oscillator



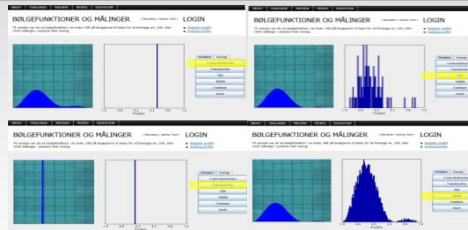
Aarhus Tech (3G), March-April 2013

focus on the concrete curriculum

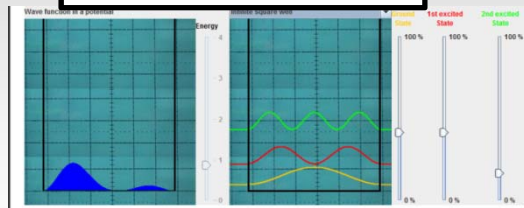
Timeline:

- Before start: pretest on basic quantum mechanics
- 20 hours block over 6 weeks including
 - Initial motivational visit
 - Group rotation intervention featuring graphical illustrations
 - Quantum computer playing session
- Directly after block: Questionnaire w/ posttest + personality test
- After 3 months: repeat posttest with questions concerning situational recollection (memory research)

Measuring the wave function



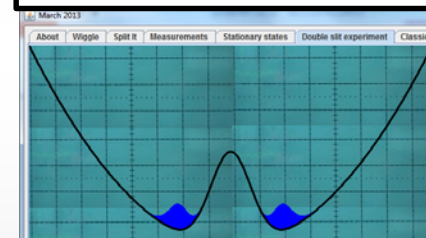
Stationary and non-stationary states



Quantum tunneling

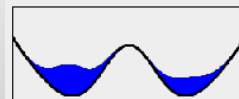


Double-slit experiment



Pop-up questions with hints

Double Well



Let the initial wave function be a 50/50 superposition of the two lowest state of a double well (Harmonic + Gaussian). Observe the time evolution of the (norm square of the) wave function and the energy spacing between the two lowest states for different heights of the Gaussian. How does the frequency of the oscillation depends on the energy difference?

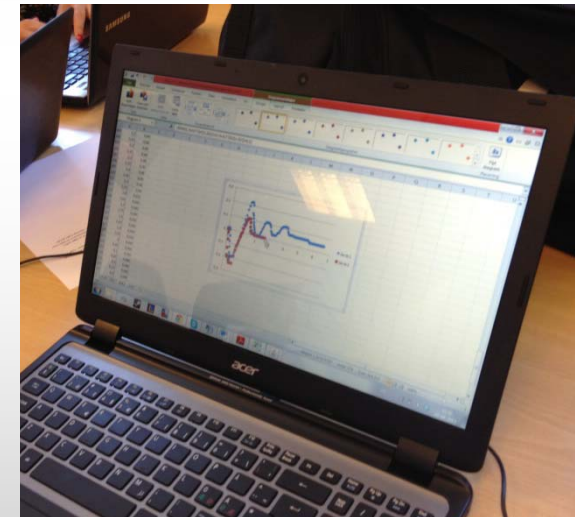
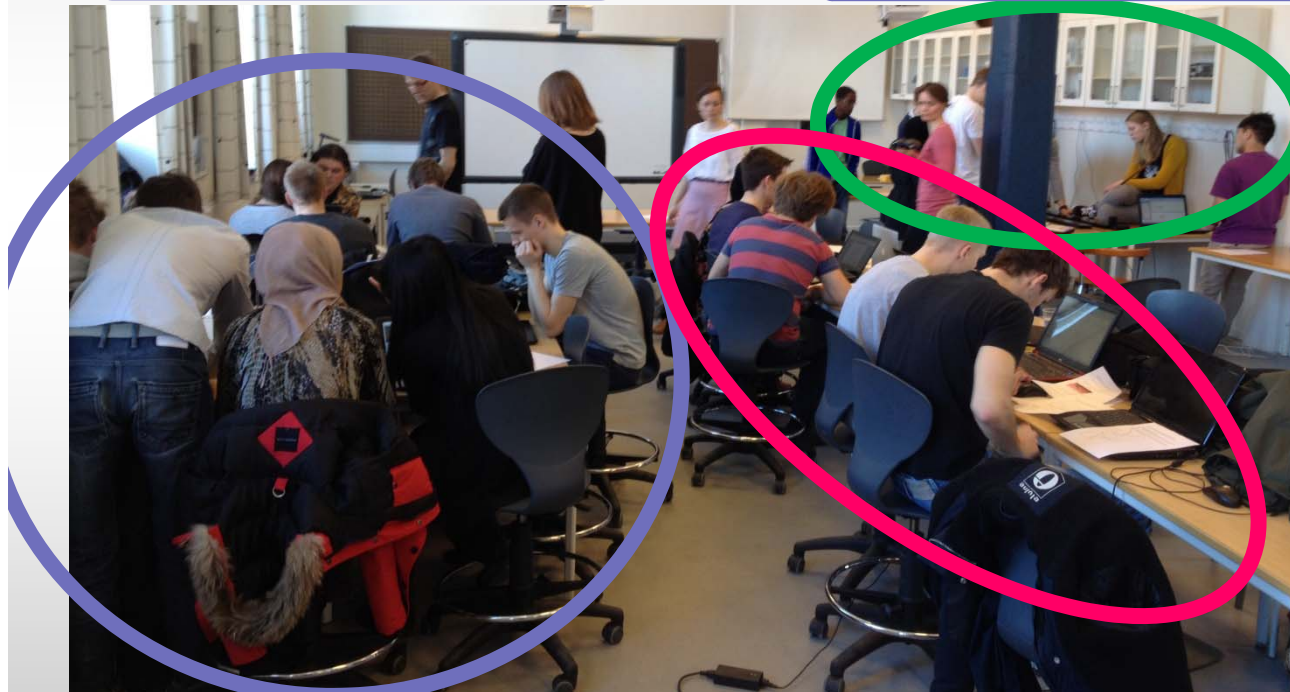
- The frequency is increased when the energy difference is increased
- The frequency is decreased when the energy difference is increased
- The frequency is independent of the energy difference

Submit

Fysik-rollespil, Aarhus Tech 2013

Simulatorer

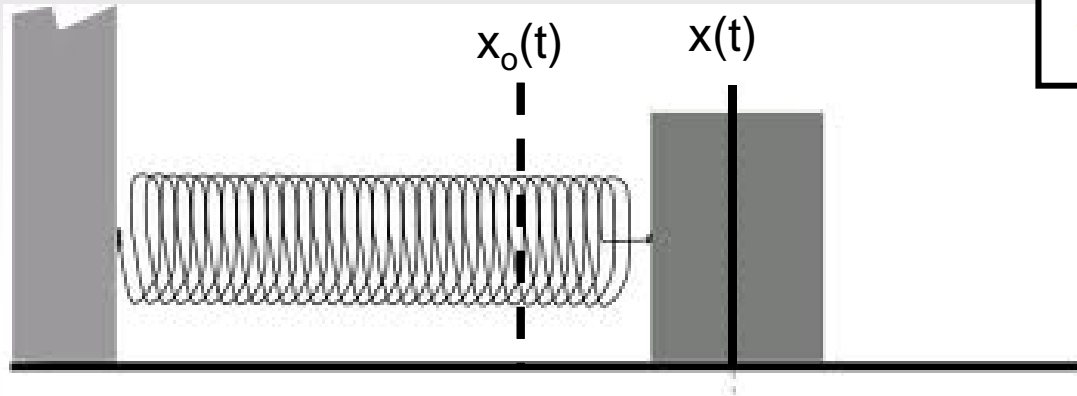
Eksperimentatorer



Teoretikere

Klassisk eksempel: Harmonisk bevægelse

Bevæg muren ifølge $x_0(t)$

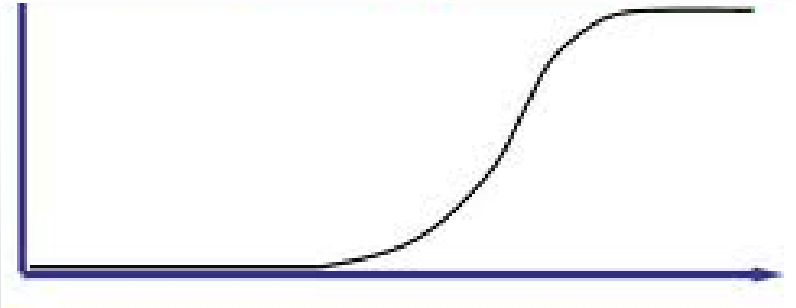


Newton's 2. lov:

$$F = m \ddot{x} = -k (x(t) - x_0(t))$$

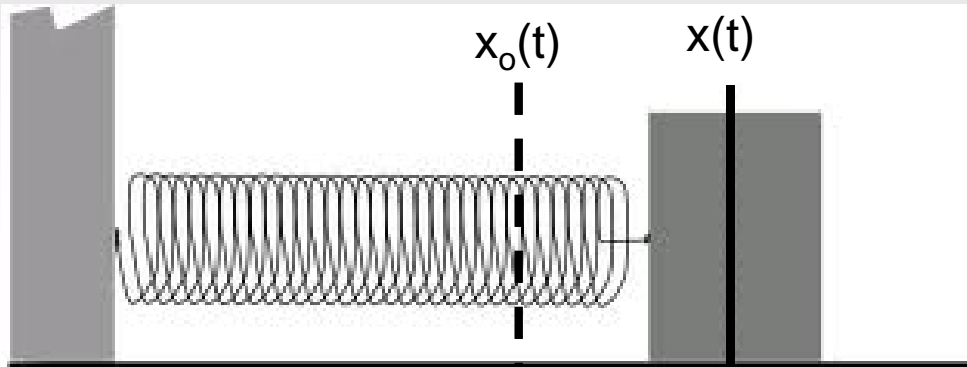
Øvelse: loddet skal bevæge sig ifølge:

$$x(t) = \frac{1}{1 + e^{-t}}$$



Klassisk eksempel: Harmonisk bevægelse

Bevæg muren med ifølge $x_o(t)$



Newtons 2. lov:

$$F = m \ddot{x} = -k (x(t) - x_o(t))$$

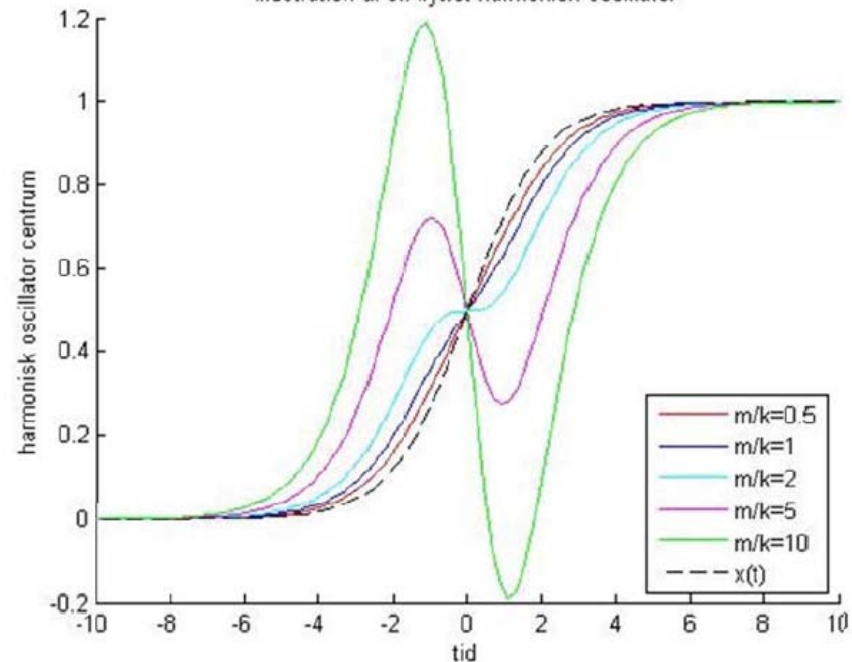
Øvelse: loddet skal bevæge sig ifølge:

$$x(t) = \frac{1}{1 + e^{-t}}$$

Hvad skal $x_o(t)$ være?

$$x_o(t) = x(t) + \frac{m}{k} \ddot{x}$$

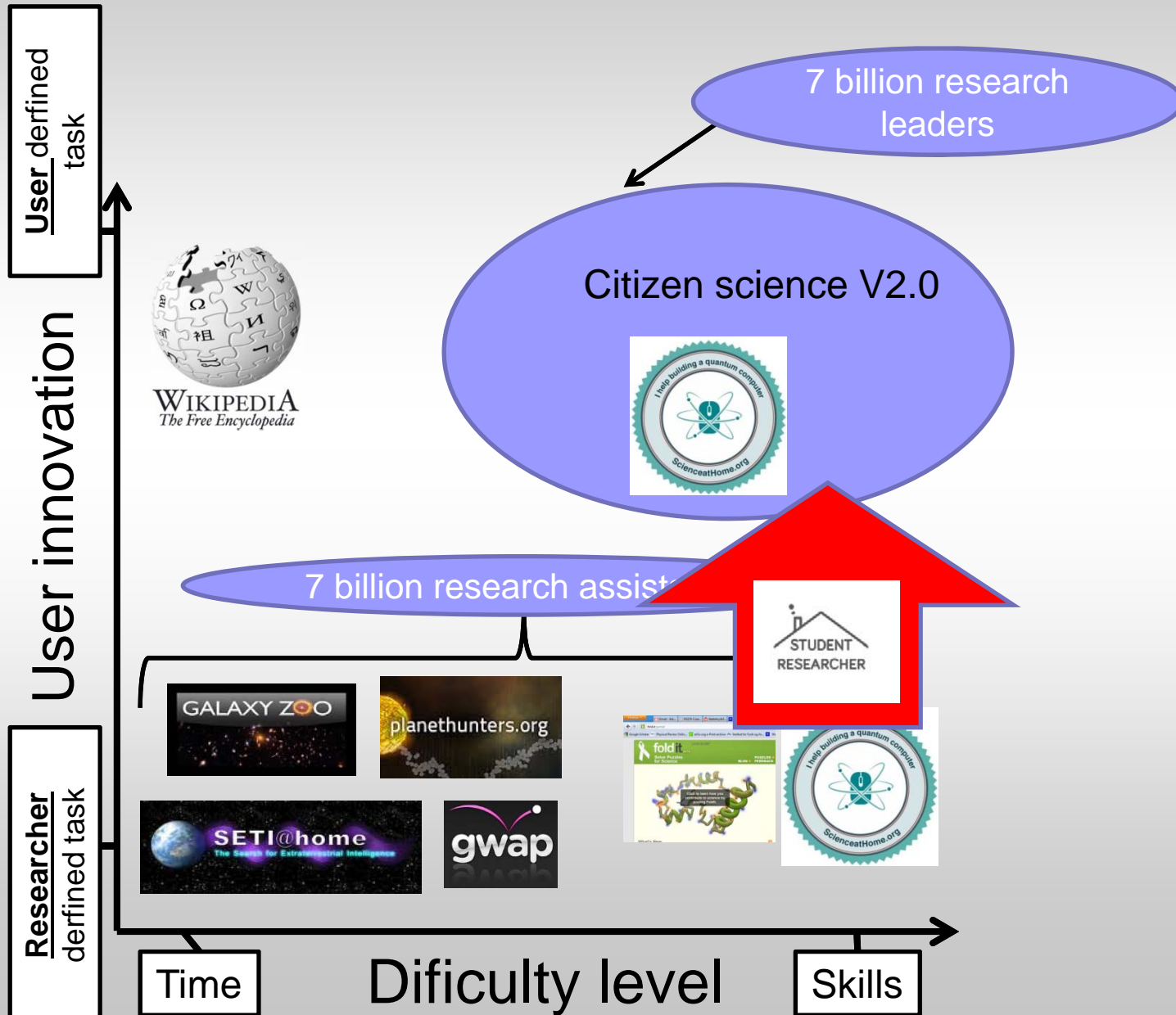
illustration af en flyttet harmonisk oscillator



Experimentatorerne



Citizen science



Ny online platform, videregående kvant 2014

QuickTime Player Arkiv Rediger Oversigt Vindue Hjælp

StudentResearcher x

scienceathome.org/studentresearcher/learning/quantumcourse/

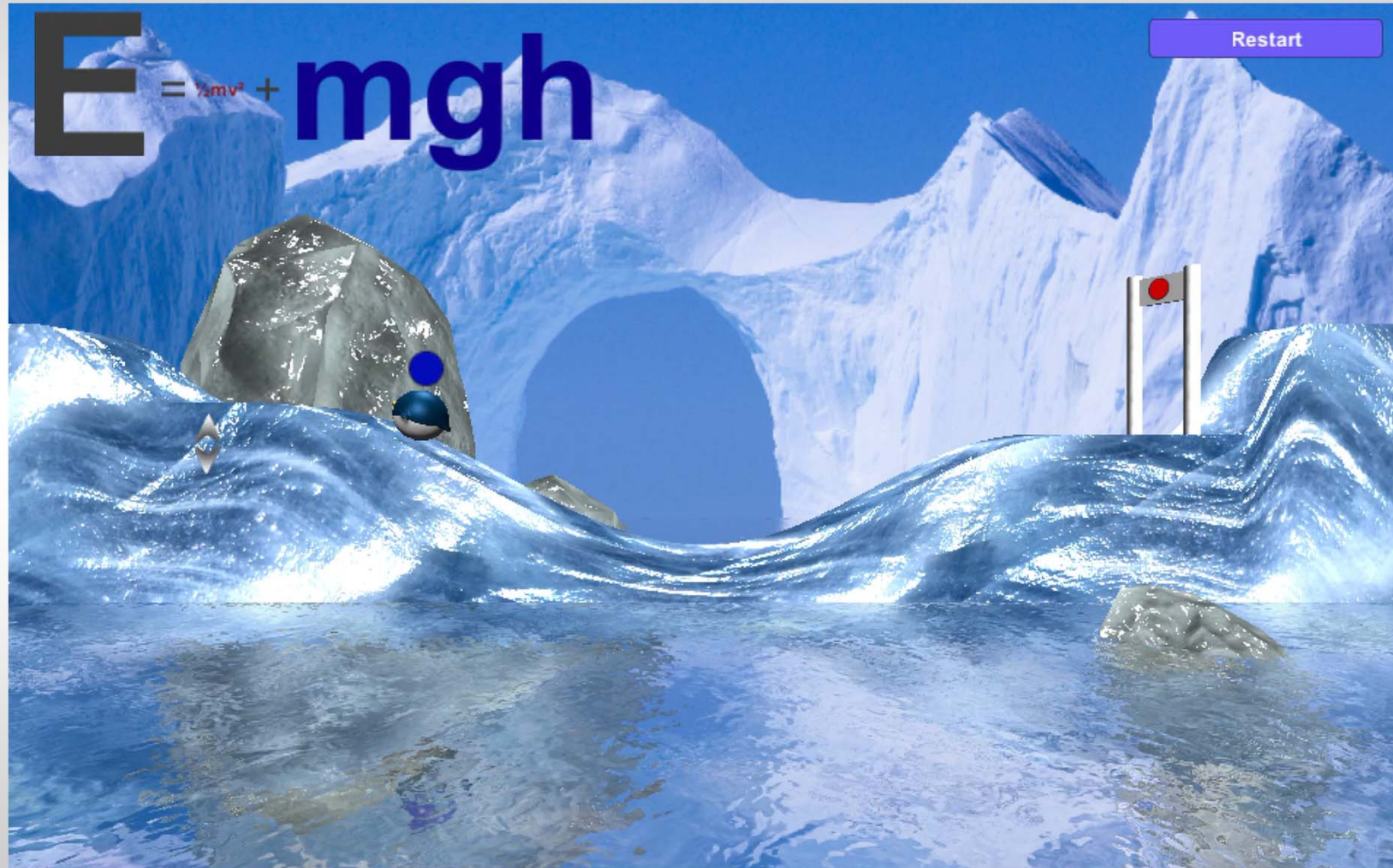
QUANTUM MECHANICS

teststudent

.....

Log in or sign up

Generalforestilling:online gymnasie forløb – potentiel og kinetisk energi



Generalforestilling:online gymnasie forløb – potentiell og kinetisk energi

student-scientist.org/learn/#?level=slide&levelid=191

SCIENCEATHOME

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Kinetic Energy

Kinetic energy E_{kin} is the energy associated to a moving object. An object standing still has no kinetic energy, but an object in motion has kinetic energy

$$E_{\text{kin}} = \frac{1}{2} mv^2$$

Kinetic energy depends on the mass m of the object, and velocity v it is moving at.

$v = 0 \text{ m/s}$ $v = 1 \text{ m/s}$
 $m = 2\text{kg}$ $m = 1\text{kg}$

Typesetting math: 100%

Tværfaglig forskning

