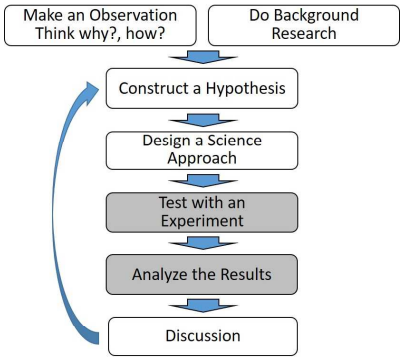
English Science

Test with an Experiment

Scientific Approach



●課題を解決するための科学的手法の１つに、「実験、観察、調査等の方法や結果を記録し、整理すること」があります。

信頼性の観点から、実験は再現可能でなければなりません。すなわち、他の研究者が同じ条件で同じ実験を行ったら、同じ結果にならなければなりません。そのため、方法では、実験の詳細（使用した材料 materials、器具 instruments、過程 procedures used、条件 conditions）を述べる必要があります。さらには、どうして特定の方法を用いたのか、どうして仮説の検証に適当なのかを伝える必要があります。

ここでは、実験結果に影響を与える他の要因（影響要因 Influence factor）を意識して実験を行い、実験結果をグラフに表現する方法を学びましょう。

補足：仮説を検証するには、実験等を行いますが、生物や地学の一部では、「再現可能」な実験を行うことができない場合があります。そのような場合でもその結果が再現可能であることを保証する統計的解析という手法があります。

1 Hypothesis & Science Approach

● Aim of your research

To confirm experimentally whether mechanical energy is conserved using a swing.

Equation of free fall: $H = \frac{1}{2} gt^2$

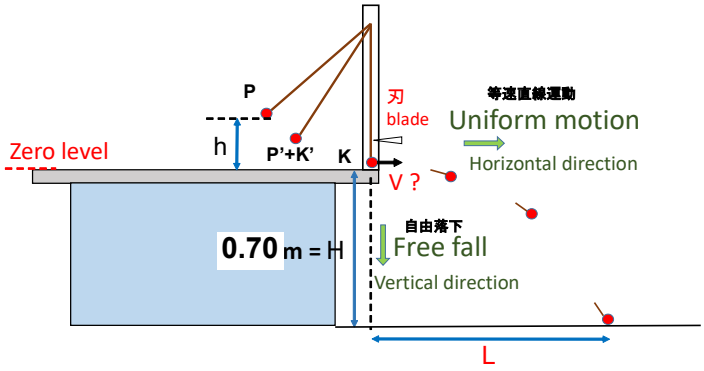


Figure 1: The motion of a ball after a string has broken

Exercise & Activity 1

The diagram above shows the the motion of a ball after a string has broken at the bottom of the swing. Use the diagram, answer the questions that follows.

【TAs Question】

Q1. At the top of the swing, what is the amount of potential energy?
⇒ mgh

Q2. At the top of the swing, what is the amount of kinetic energy?
⇒ 0

Q3. At the top of the swing, what is the amount of mechanical energy?
⇒ mgh

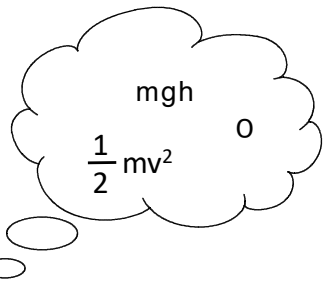
Q4. At the bottom of the swing, what is the amount of potential energy? ⇒ 0

Q5. At the bottom of the swing, what is the amount of kinetic energy?
⇒ $\frac{1}{2}mv^2$

Q6. At the bottom of the swing, what is the amount of mechanical energy? ⇒ $\frac{1}{2}mv^2$

【Your Answer】

Q1.～ Q6.



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Exercise & Activity 2

1. After the string has broken, in the vertical direction, the motion of the ball is in free fall. If the height of the desk is 0.70m, calculate the time taken to reach the floor. Use g = 9.8 [m/s^2].

Solution

hint : $H = \frac{1}{2} gt^2$ $t = \sqrt{2H/g} = \sqrt{2 \times 0.810/9.80} = 0.378$ [s]

Ans. 0.378 [s]

2. In the horizontal direction, what is the motion of the ball?

Ans. Uniform motion

3. If the ball moves L[m] to the horizontal direction when the ball hits the floor, represent V using L.

Solution

Ans. $V = \frac{L}{0.378}$ [m/s]

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Hypothesis & Design a Science Approach

In order to test this hypothesis, you design the following experiment (Figure 1).

Hypothesis	:	The gravitational potential energy at the top of the swing is equal to the kinetic energy at the bottom of the swing.
Independent variable	:	The height of a ball at the top of the swing
Dependent variable	:	The velocity of a ball at the bottom of the swing
Methods	:	Measure the gravitational potential energy at the top of the swing and the kinetic energy at the bottom of the swing. Then compare the amount of both energies.

2 Test with an Experiment

Exercise & Activity 3

Create a table in which to record your data, then start the experiment.

Trial	m[kg]	h[m]	U[J]	L[m]	v[m/s]	v^2	K[J]
1							
2							
3							
4							
5							
Average							

3 Analyze the Results - Present your data in a useful format -

In order to express the results of an experiment more exactly, error bars which represent the uncertainty or variation of the corresponding coordinates of each point are put on the graph.

Organizing Data

Exercise 2 Use the data below, put the error bar on a dot. h=0.15 and h=0.20 are done for you.

Table 1 : Relationship between height and v^2 (n=10)

h [m]	V^2 [m^2/s^2]										average	SD
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	[m^2/s^2]	
0.10	2.04	1.88	1.99	1.96	1.96	2.10	1.93	1.54	1.90	2.02	**1.93**	**0.15**
0.15	2.79	2.76	2.82	2.34	2.89	2.86	2.89	2.86	2.89	2.92	**2.80**	**0.17**
0.20	4.20	3.69	4.04	3.50	4.12	3.72	3.88	3.96	4.08	4.12	**3.93**	**0.23**

error bar

Average + SD
Average
Average - SD

標準偏差
Standard deviation (SD) $= \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2}$

Constructing Graphs

x-axis ⇒ independent variable
y-axis ⇒ dependent variable

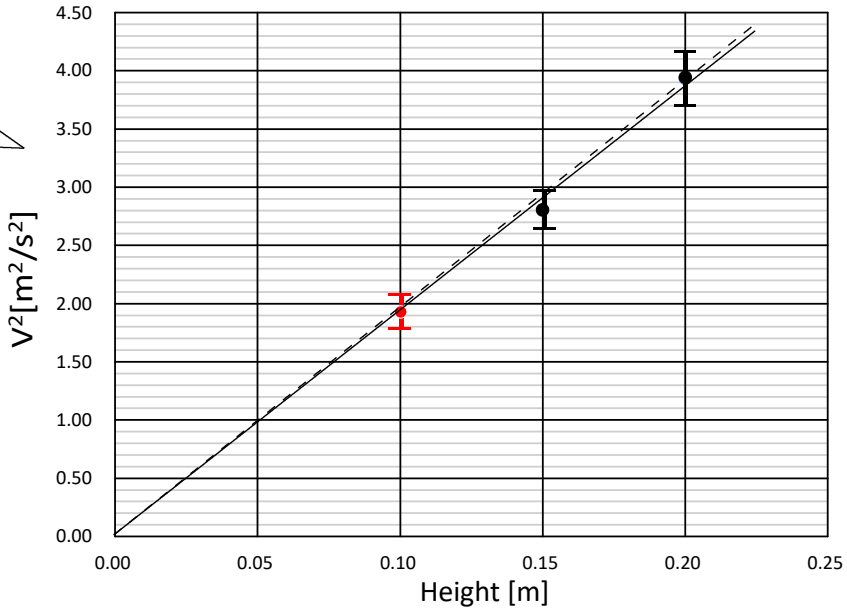


Figure 2 : Relationship between height and v^2 (n=10)

【Vocabuluary】

Spelling	POS	Meaning	
work	noun	仕事	
distinctly	adv	はっきりと、明瞭に	
force	noun	力	
act	verb	働く、作用する	
object	noun	物体	
displacement	noun	変位	
direction	noun	方向	
scalar quantity	noun	スカラー	
joule	noun	ジュール《エネルギーの単位》	
magnitude	noun	大きさ	
unit	noun	単位	
classify	verb	分類する	
kinetic energy	noun	運動エネルギー	
motion	noun	動き、運動	
mass	noun	質量	
velocity	noun	速度	
depends on		(によって)決まる	
travel	verb	進む、動く	
identical	adj	同一の	
gravitational potential energy	noun	重力による位置エネルギー	
gravity	noun	重力	
store	verb	蓄える	
vertical height	noun	鉛直高さ	
rest	verb	静止している	
gravitational field	noun	重力場	
times	verb	かける	
free-fall acceleration	noun	重力加速度	
arbitrary	adj	任意の	
zero level	noun	ゼロ レベル	
absence	noun	ないこと	
friction	noun	摩擦力	
mechanical energy	noun	力学的エネルギー	
principle	noun	原理、法則	
conservation of mechanical energy	noun	力学的エネルギーの保存	
convert	verb	変換する	
uniform motion	noun	等速直線運動	
A **is proportional to** B		A は B に比例する	

【Presentation Exercise】 Let's try to have a presentation using the following slides and script.

Introduction

The Relationship between Kinetic Energy and Gravitational Potential Energy

Aim of research

To confirm experimentally whether mechanical energy is conserved.

・Hello everyone! My name is ・・・

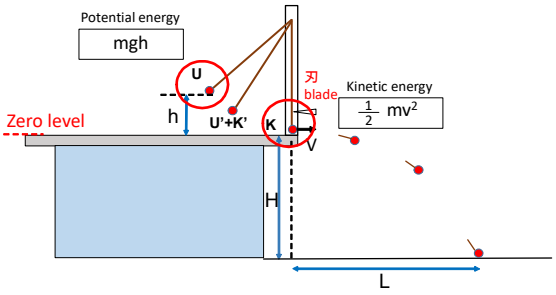
・Today I'm going to talk about the relationship between Kinetic Energy and Gravitational Potential Energy.

・In order to confirm whether mechanical energy is conserved, we designed the following experiment.

Body 1

Methods

Kinetic energy(E_K) & Gravitational potential energy(E_P)



・By making these kinds of apparatus, we measured the potential energy at the top of the swing and the kinetic energy at the bottom of the swing.

Body 2

Results

$V = \frac{L}{0.405}$

	m[kg]	h[m]	U[J] mgh	L[m]	V[m/s]	V^2	K[J] $mV^2/2$
Group 1	0.36	0.20	0.70	0.75	1.8	3.4	0.61
Group 2	0.36	0.20	0.70	0.77	1.9	3.6	0.64
Group 3	0.36	0.20	0.70	0.80	2.0	3.9	0.69
Group 4	0.067	0.20	0.13	0.80	2.0	3.9	0.13
Group 5	0.067	0.20	0.13	0.79	2.0	3.8	0.13
Group 6	0.36	0.15	0.53	0.65	1.6	2.5	0.46
Group 7	0.36	0.15	0.53	0.65	1.6	2.5	0.46
Group 8	0.067	0.15	0.10	0.64	1.6	2.5	0.084
Group 9	0.067	0.15	0.10	0.69	1.7	2.9	0.10
Group 10	0.067	0.15	0.10	0.69	1.7	2.9	0.10

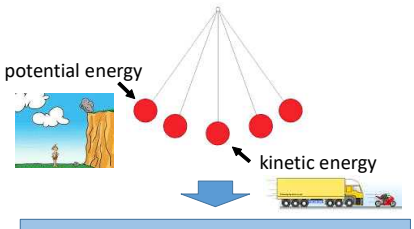
・Look at this table.

・This is the result of our experiment.

・From our experiment, we could say that the amount of potential energy at the top of the swing is almost equal to the amount of kinetic energy at the bottom of the swing.

Conclusion

Conclusion



Conservation of mechanical energy

・This relationship is called conservation of mechanical energy.

・Thank you for listening.