Pendulum

by

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P4.3A Identify the form of energy in given situations (e.g., moving objects, stretched springs, rocks on cliffs, energy in food).

P4.3B Describe the transformation between potential and kinetic energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts).

Items;

1- Pendulum

2- Period of Pendulum

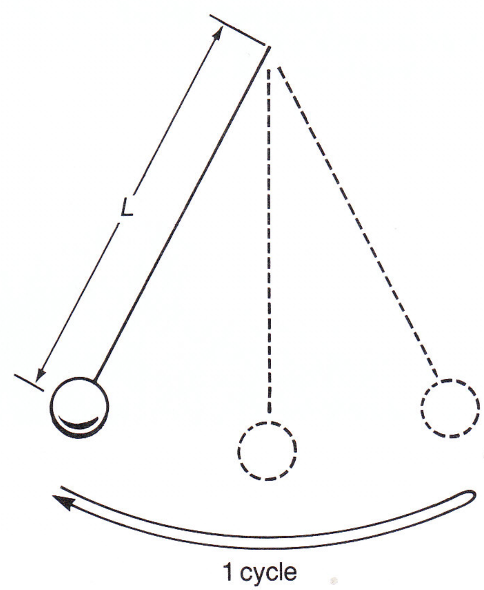
3- Transformation of Energy

4- Period of Planets

Pendulum

T is the period of the pendulum. It is the time for one cycle measured in seconds. One complete cycle is one period.

L is the length of the pendulum, measured from top end of the string to the center of the bob, in meters.



The period of a pendulum is given by the following equation:

Period of a Pendulum
$$T \approx 2\pi\sqrt{\frac{L}{g}}$$

g is the acceleration due to gravity. The unit of *g* is meter per second square.

On the Earth, *g* up is 9.8 m/s^2 , *g* down is -9.8 m/s^2

- Π = 3.14. It is a constant

A pendulum 1.0 m long is used in some grandfather clocks. Each half cycle marks on second. A clockwork motor gives the pendulum a small push at the right moment during each swing, to keep it going.

Example 1: *Grandfather Clock.*

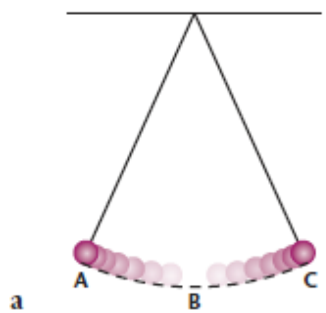
A pendulum 1.0 m long is used in a grandfather clock. What is the period of a pendulum 1.0 m long?

$$
\begin{aligned}
T &= 2\pi\sqrt{\frac{L}{g}} \\
&= 2\pi\sqrt{\frac{1.0\ \text{m}}{9.8\ \text{m/s}^2}} \\
&= 2\pi\sqrt{0.102\ \text{s}^2} \\
&= 2(3.14)\ (0.319\ \text{s}) \\
&= 2.0\ \text{s}
\end{aligned}
$$

The period of a pendulum 1.0 m long is 2.0 seconds.

Pendulum,
Transformation of Energy
Conservation of Mechanical Energy

The transformation between potential and kinetic energy in the simple oscillation of a pendulum bob is shown in figures a and b (below).



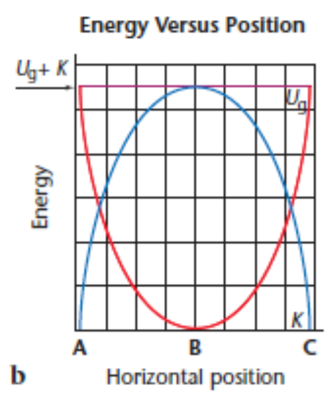
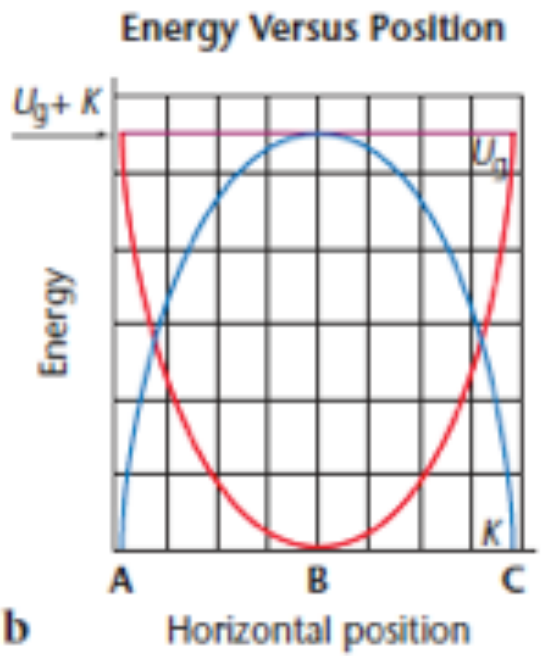


Figure b, is the energy versus position graph. It shows the transformation between the potential energy (Ug, red graph) and kinetic energy (K, blue graph) as well as the conservation of the total mechanical energy (K + Ug, purple line) in positions A, B and C. Notice that the value of the mechanical energy remains constant as depicted by the straight purple line.



b

Period of a Planet

A planet of mass m is revolving around the sun of mass M, the centripetal force is

$$F_C = m\, a_c$$

a_c : centripetal acceleration;

Using Newton's Law of Universal Gravitation, the force of attraction:

$$F_C = G\, m\, M / r^2$$

r = distance to the sun

$$m\, a_c = G\, m\, M / r^2$$

$$a_c = GM / r^2$$

we know that :

$$T \approx 2\pi\sqrt{\frac{L}{g}}$$

In this case:

$$g = a_c = GM / r^2$$

$$L = r$$

Replacing g and L by their values in the formula of period:

$$T \approx 2\pi\sqrt{\frac{L}{g}}$$

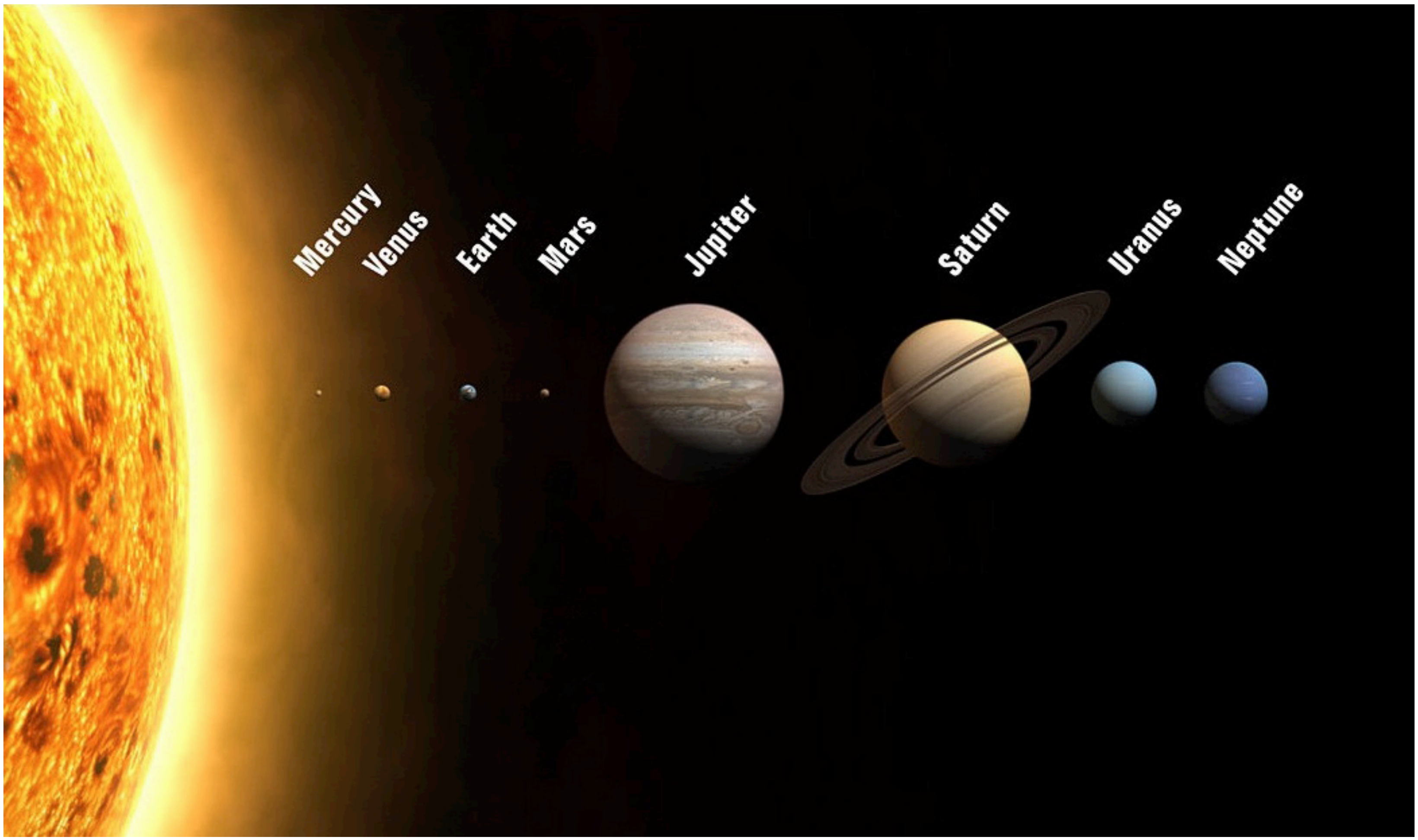
Orbital Period
$\tau = 2\pi\sqrt{\frac{r^3}{GM}}$

G = 6.673 x10^{-11} N.m ^{2}/kg^2

M = Mass of the sun 1.99 x 10^{30} kg

Example 2: Orbital Period of Earth

The distance from Earth to Sun is 1.5×10^{11} m. Find the orbital period of Earth.



Data Table			
r	*G*	*M sun*	*t*
1.5 x 10^{11} m	6.673 x10^{-11}	1.99 x 10^{30} kg	?

The orbital period is:

$$\tau = 2\pi\sqrt{\frac{r^3}{GM}}$$

$$\tau_{\text{Earth}} = 2\pi\sqrt{\frac{\left(1.5\times10^{11}\right)^3}{\left(6.67\times10^{-11}\right)\left(1.99\times10^{30}\right)}} = 3.2\times10^{7}\ \text{s}$$

One year is 365 days = (365 x 24 x 60 x 60) second = 3.1563000 s or 3.2 x 10^7 s

References:

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Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current.* *www.physics.ohio-state.edu/~humanic/*

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The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

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