TRINITY COLLEGE FOR WOMEN
NAMAKKAL
Department of Physics

SOLAR ENERGY UTILIZATION

23PPHP02 - ODD Semester

Presented by

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Simple Pendulum

$$\omega = \sqrt{\frac{g}{L}} \text{ . Since, } \omega = \frac{2\pi}{T}$$

we get: $$T = 2\pi \sqrt{\frac{L}{g}}$$

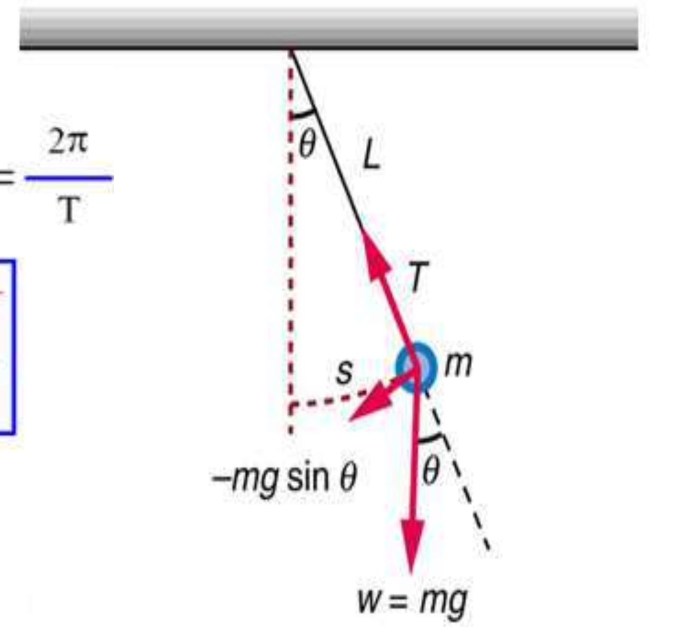


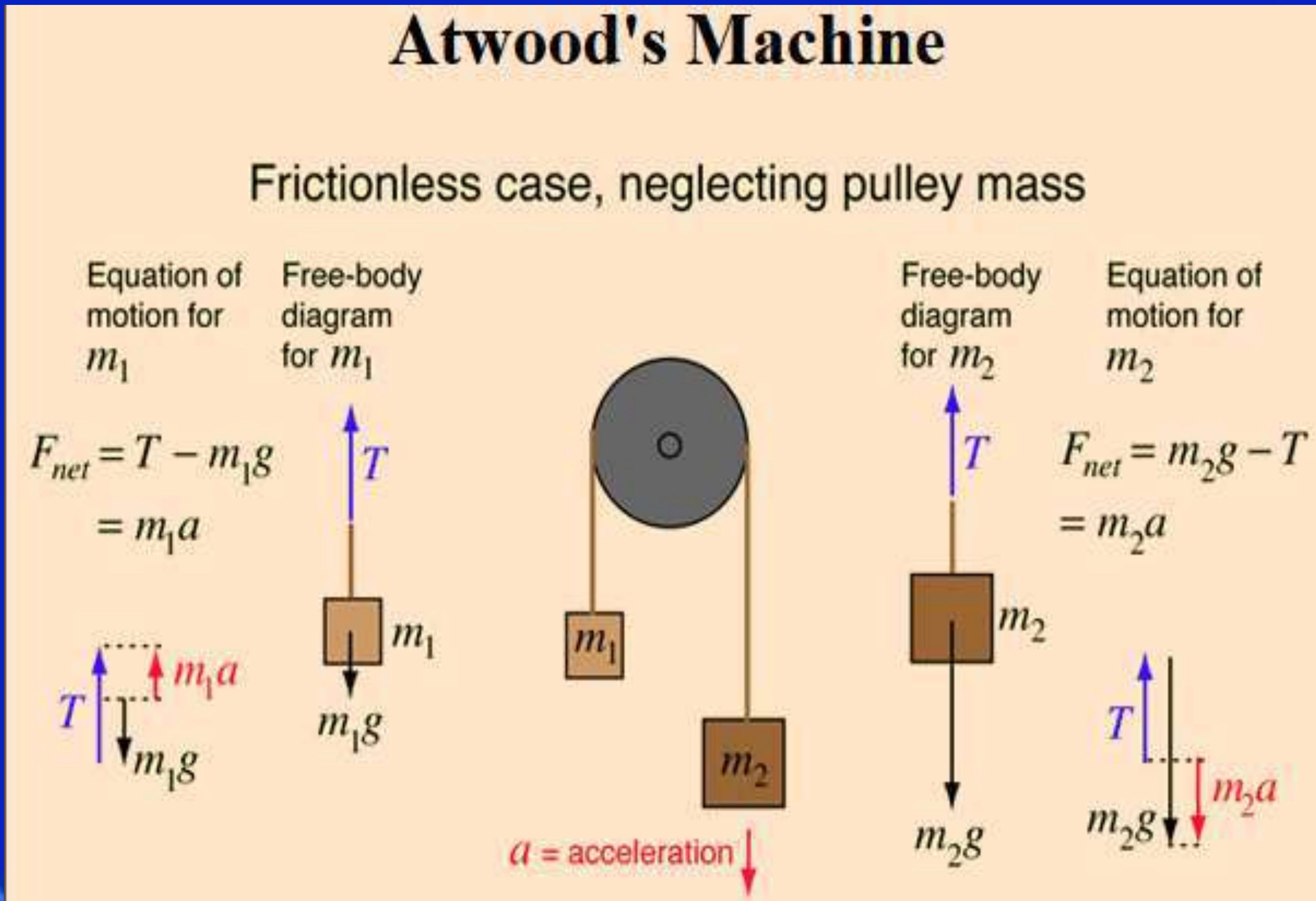
Figure 2 - Simple Pendulum Forces Diagram

Source

$$L = K - V$$
$$L = \frac{1}{2} ml^2\dot{\theta}^2 - mgl(1 - \cos\theta)$$
$$L = \frac{1}{2} ml^2\dot{\theta}^2 + mgl\cos\theta - mgl$$

Next, we plug this value into the Euler Lagrange equation, noting that q = θ. Thus,

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) - \frac{\partial L}{\partial \theta} = 0$$
$$\frac{\partial L}{\partial \dot{\theta}} = ml^2\dot{\theta}$$
$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}}\right) = ml^2\ddot{\theta}$$
$$\frac{\partial L}{\partial \theta} = -mgl\sin\theta$$
$$\therefore \qquad ml^2\ddot{\theta} = -mgl\sin\theta$$
$$\text{Or,} \qquad \ddot{\theta} = -\frac{g}{l}\sin\theta$$



Atwood's Machine
Frictionless case, neglecting pulley mass
Equation of motion for m_1
Free-body diagram for m_1
Free-body diagram for m_2
Equation of motion for m_2
$F_{net} = T - m_1 g$
$= m_1 a$
$F_{net} = m_2 g - T$
$= m_2 a$
T
$m_1 a$
$m_1 g$
m_1
m_2
$m_2 g$
$m_2 a$
a = acceleration

For this idealized case the tension T is the same on both sides of the pulley. The acceleration a is the same for both masses. Solving for T gives:

$$T = m_1 g + m_1 a$$

Substituting T into the equation for m_2 gives

$$m_2 g - m_1 g - m_1 a = m_2 a$$

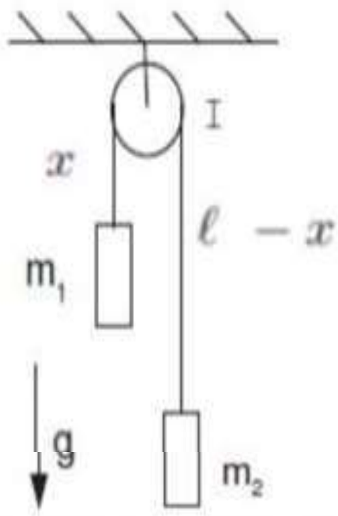
The equation of motion for the two-mass system is then:

$$(m_2 - m_1)g = (m_1 + m_2)a \quad \text{or} \quad a = \frac{(m_2 - m_1)g}{(m_1 + m_2)}$$

Consider the double Atwood machine. We assume that

1. the pulley is light, so we can ignore their kinetic energy; and
2. the rope do not slip (or they slide without friction).

The system has only one degree of freedom.



The kinetic and potential energy of the three blocks are

$$T_1 = \frac{1}{2} m_1 \dot{x}^2$$
$$T_2 = \frac{1}{2} m_2 (-\dot{x})^2$$
$$V_1 = -m_1 g x$$
$$V_2 = -m_2 g(\ell - x)$$

The lagrangian becomes

$$L = \frac{1}{2}(m_1 + m_2)\dot{x}^2 + m_1 g x + m_2 g(\ell - x)$$

Constraints:

The limitations on the motion are often called *constraints*.

Holonomic Constraints:

If all constraints of the system can be expressed as equations having the form $\phi\left(q_1, q_2, \ldots, q_n, t\right)=0$ or their equivalent, then the system is said to be *holonomic*; otherwise the system is said to be *non- holonomic*.

Example 1:

A cylinder rolling without slipping down a rough inclined plane of angle α .

Example 2:

A horizontal cylinder of radius a rolling inside a perfectly rough hollow horizontal cylinder of radius $b>a$.

Example 3:

A particle constrained to move along a line under the influence of a force which is inversely proportional to the square of its distance from a fixed point and a damping force proportional to the square of the instantaneous speed.

Non-Holonomic Constraints:

Any constraints that must be expressed in terms of the velocities of the particles in the system are of the form $\phi\left(q_1, q_2, \ldots, q_n; \dot{q}_1, \dot{q}_2, \ldots, \dot{q}_n; t\right) = 0$
and constitute non-holonomic constraints unless the equations can be integrated to yield relations among the coordinates.

Example 1:
A sphere constrained to roll on a perfectly rough plane.
Example 2:
A sphere rolling down from the top of a fixed sphere.
Example 3:
A cylinder rolling [and possibly sliding] down an inclined plane of angle α .
Example 4:
A sphere rolling down another sphere which is rolling with uniform speed along a horizontal plane.

SCLERONOMIC CONSTRAINTS:

The constraints which are independent of time are called scleronomic constraints e.g. a bead sliding on a rigid curved wire fixed in space

RHEONOMIC CONSTRAINTS

The constraints which contain time explicitly are called rheonomic constraints. e.g.
1) a bead sliding on a rigid curve wire moving in some prescribed fashion.
2)if we construct a simple pendulum whose length changes with time
i.e. $l=l(t)$ then the constraints expressed by the equations are time dependent, hence, rheonomic .

THANK YOU

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