Spring 2014

PHYS-2010

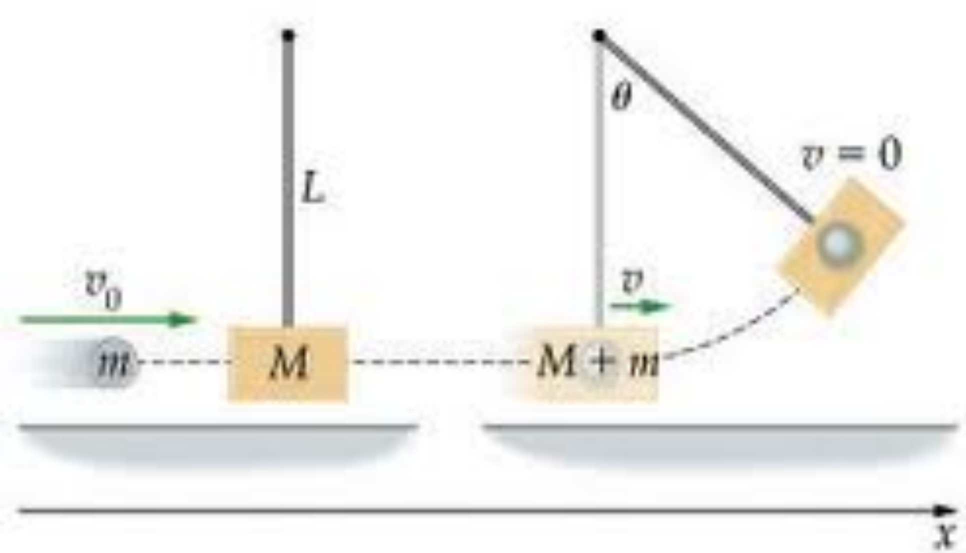
Lecture 31

Clicker Question

Room Frequency BA

Ballistic Pendulum

A bullet of mass **m** with initial horizontal velocity $\mathbf{v_0}$ is fired into a large suspended block of mass **M**.



Which of the following is true for the initial collision?

A) Only energy is conserved

B) Only momentum is conserved

C) Only kinetic Energy is conserved

D) Energy and momentum are conserved

E) Kinetic energy and momentum are conserved

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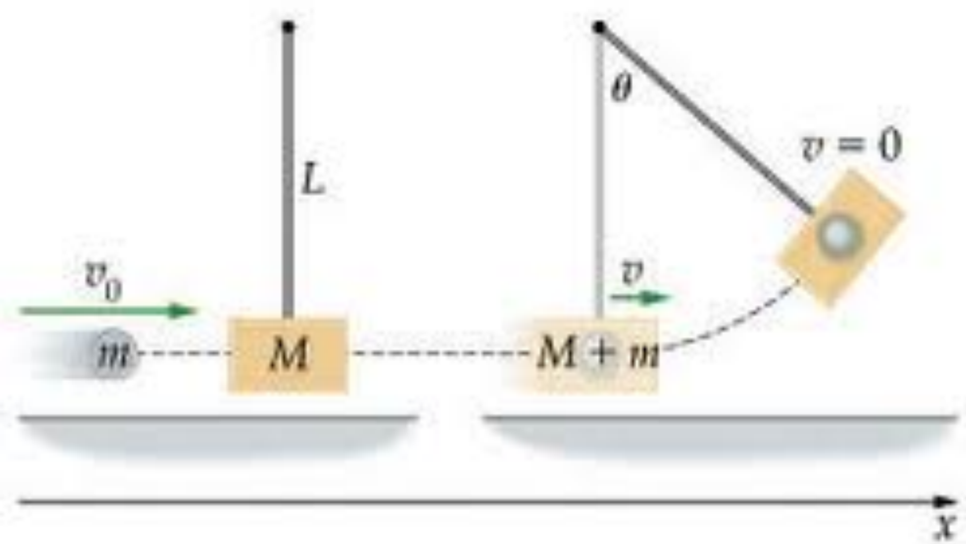

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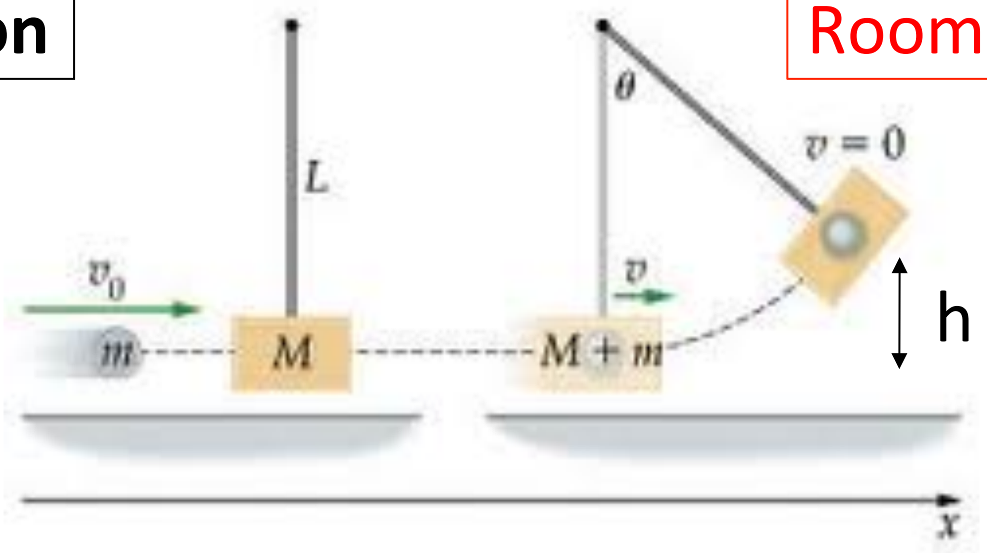

For the initial collision where the bullet hits and gets stuck in the pendulum, can there be zero thermal energy generated?

A) Yes

B) No

Impossible

$$KE_i + PE_i \stackrel{?}{=} KE_f + PE_f$$

$$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}(M+m)v^2 + 0 \Rightarrow v = \sqrt{\frac{m}{M+m}}v_0$$

$$mv_0 = (M+m)v \Rightarrow v = \frac{m}{M+m}v_0$$

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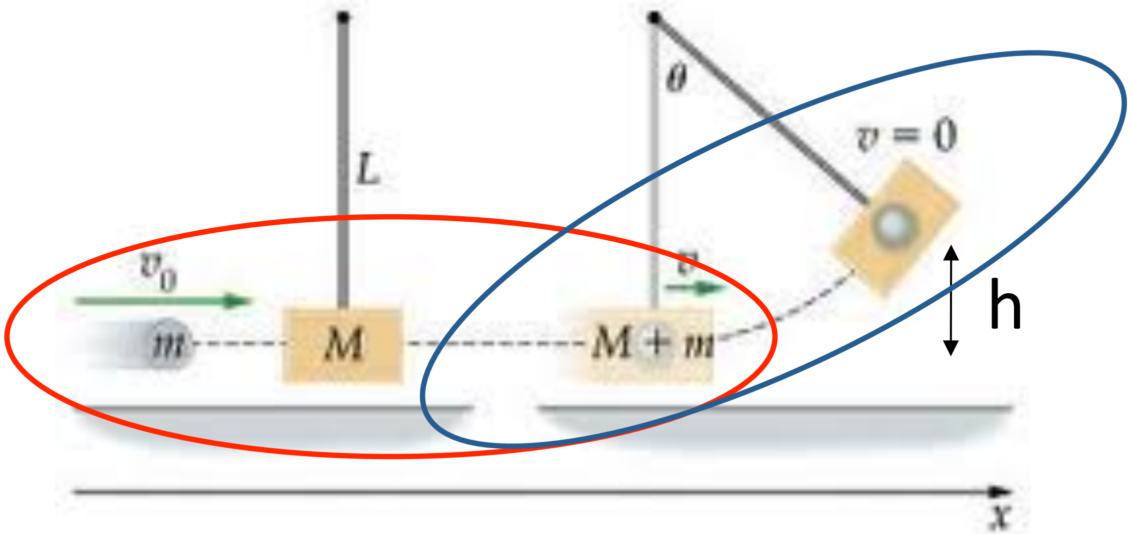


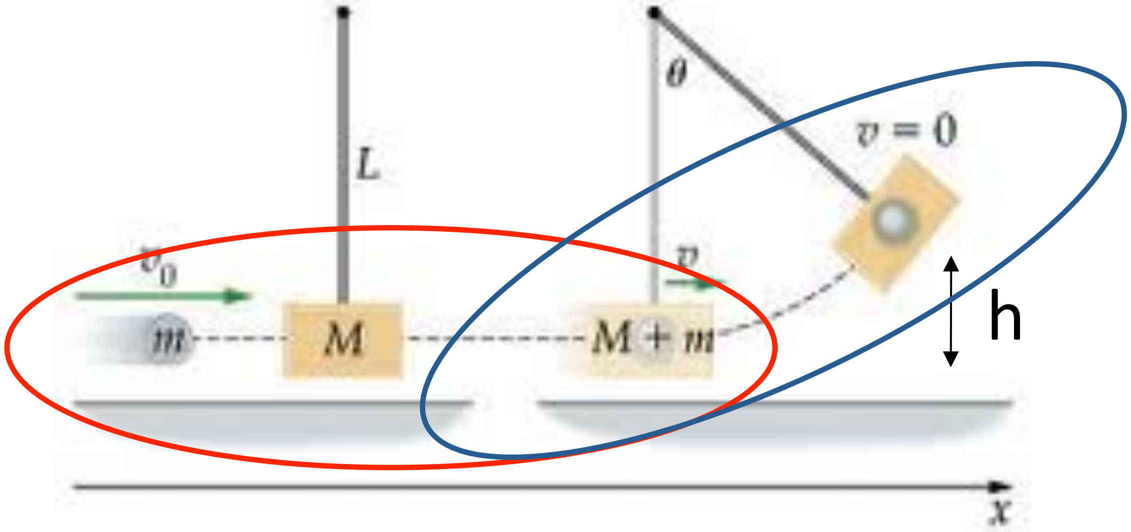
Is the momentum of the system (M+m) conserved for the second (blue oval) part?

A) Yes

B) No

No, because an external net force is acting (gravity+tension)!

We say so often the momentum is conserved, but it clearly cannot be if a net external force is acting on the system.



However:

(1) gravity is a conservative force

(2) tension does no work in this case (why?)

Hence, the total mechanical energy is still conserved.

$$KE_i + PE_i = KE_f + PE_f$$

$$\frac{1}{2}(M+m)v^2 + 0 = (M+m)gh$$

$$h = \frac{v^2}{2g}$$

Announcements

- Read Giancoli **Chapter 8 on Rotational Motion**.
- **CAPA # 10 deadline postponed until Thursday 11 pm !!!**
- Next CAPA # 11 due April 8.
- Written **Homework # 8** due this Friday, April 4.
- Next week: Review Recitation and **missed Lab make-up.**

  - at least 7 labs are required to pass the course;

  - contact your TA to arrange lab makeup ahead of time. You will need to attend twice: (1) for lab make-up; and (2) for review recitation. You can attend any other section (in addition to your regular one), with that section's TA permission.

- **Study Session** by Prof. Pollock: Tue, Apr. 8, 5-6pm, G125.
- **Midterm Exam 3** on Thursday, April 10, 7:30 pm.

Clicker Question

Room Frequency BA

Translation	$\leftrightarrow$	Rotation	
x	$\leftrightarrow$	θ	angle of rotation (rads)
$v = \frac{\Delta x}{\Delta t}$	$\leftrightarrow$	$\omega = \frac{\Delta\theta}{\Delta t} = \frac{v}{r} = \frac{2\pi}{\tau} = 2\pi f$	angular velocity (rad/s)
$a = \frac{\Delta v}{\Delta t}$	$\leftrightarrow$	$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_{tan}}{r}$	angular acceleration (rad/s^2)

Recall that centripetal acceleration is expressed in terms of tangential velocity as: $a_r = v^2/r$. How is it expressed in terms of angular velocity ω?

A) $a_r = \omega^2/r$

B) $a_r = r\omega$

C) $a_r = r\omega^2$

D) $a_r = r^2\omega^2$

$a_r = v^2/r = (r\omega)^2/r = r\omega^2$

Rotational Kinematics

Translation	$\leftrightarrow$	**Rotation**	
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Constant acceleration *a*:		Constant angular acceleration α:
$v = v_0 + at$	$\leftrightarrow$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_o t + \frac{1}{2}at^2$	$\leftrightarrow$	$\theta = \theta_0 + \omega_o t + \frac{1}{2}\alpha t^2$
$v^2 = v_0^2 + 2a\Delta x$	$\leftrightarrow$	$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

Clicker Question

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What is the magnitude of the angular acceleration α of a wheel spinning at constant rate?

A) zero

B) v^2/R

C) g

D) 2π R/T

E) None of these

There is a non-zero ***centripetal*** acceleration, but the ***angular*** acceleration is zero because the wheel's angular velocity is constant!

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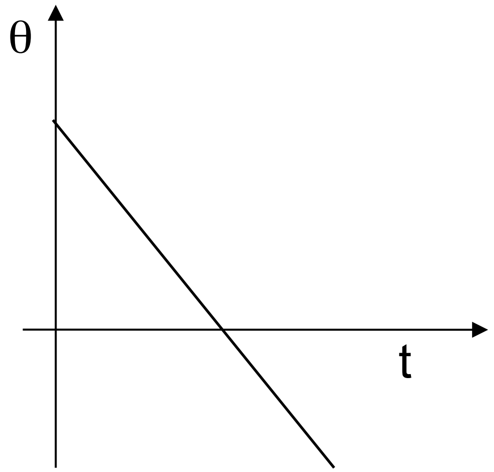
The graph shows angle θ vs. time t of a wheel spinning around a fixed axis.



The graph shows:

A) ω = constant, α = 0

B) ω increasing, α > 0

C) ω decreasing, α < 0

D) None of these

Clicker Question

Room Frequency BA

A space ship is initially rotating on its axis with an angular velocity of ω_0 = 0.5 rad/sec. The Captain creates a maneuver that produces a constant angular acceleration of α = 0.1 rad/sec^2 for 10 sec.

$$\omega = \omega_0 + \alpha t$$
$$= \frac{v}{r} = \frac{2\pi}{\tau} = 2\pi f$$
$$\theta = \theta_0 + \omega_o t + \frac{1}{2}\alpha t^2$$
$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

1) What is its angular velocity at the end of this maneuver?

A) 1 rad/sec

B) 1.5 rad/sec

C) 0.6 rad/sec

D) 5 rad/sec

$$\omega = \omega_0 + \alpha t = 0.5 \text{ rad/sec} + (0.1 \text{ rad / sec}^2)(10 \sec) = 1.5 \text{ rad/sec}$$

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$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

1) What is its angular velocity at the end of this maneuver? $\omega = 1.5 \text{ rad/sec}$

2) At how many rpms is it rotating after the maneuver?

A) 10 rpm B) (30/π) rpm C) (45/π) rpm D) π rpm

$$f = \frac{\omega}{2\pi}\frac{revols}{\text{sec}} = \frac{1.5}{2\pi}\frac{revols}{\text{sec}}\left(\frac{60\,\text{sec}}{\text{min}}\right) = \frac{45}{\pi}\frac{revols}{\text{min}} = \frac{45}{\pi}rpm$$