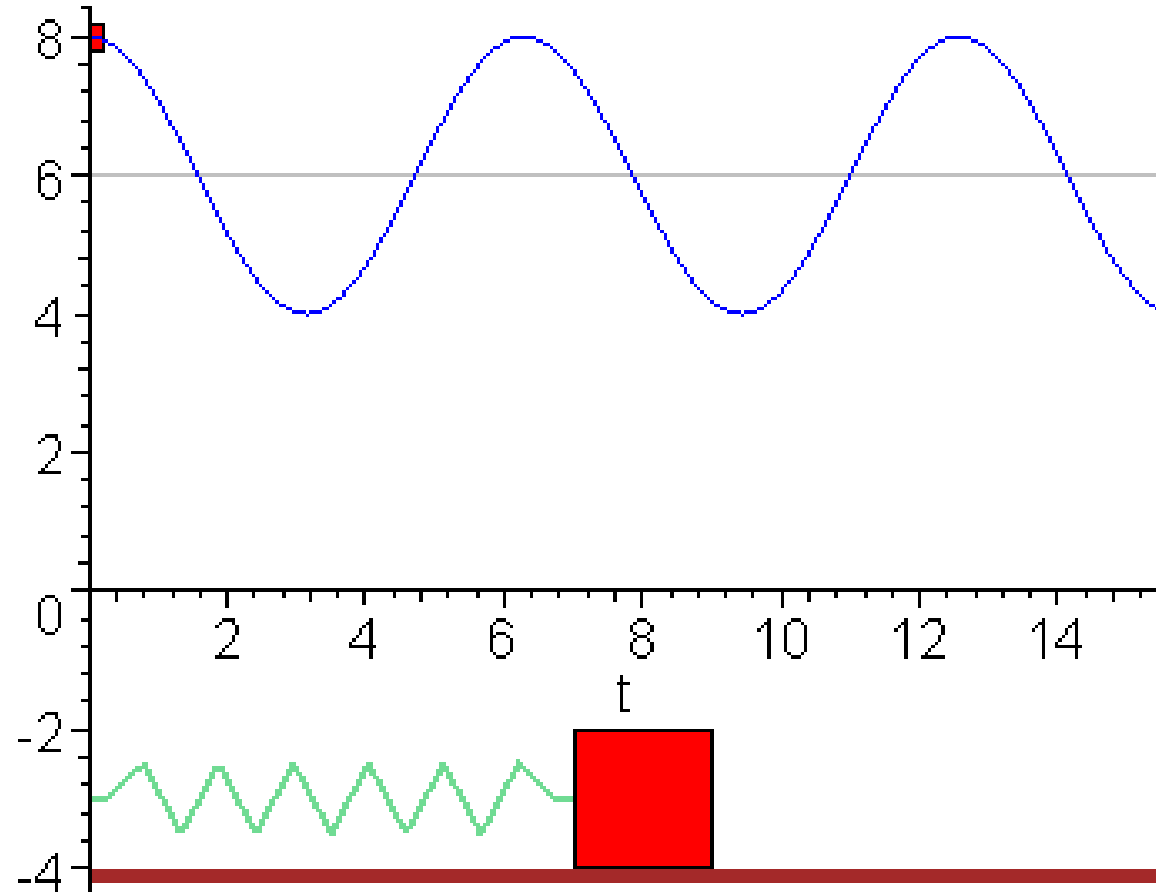


# PHY131H1F - Class 20

Today:

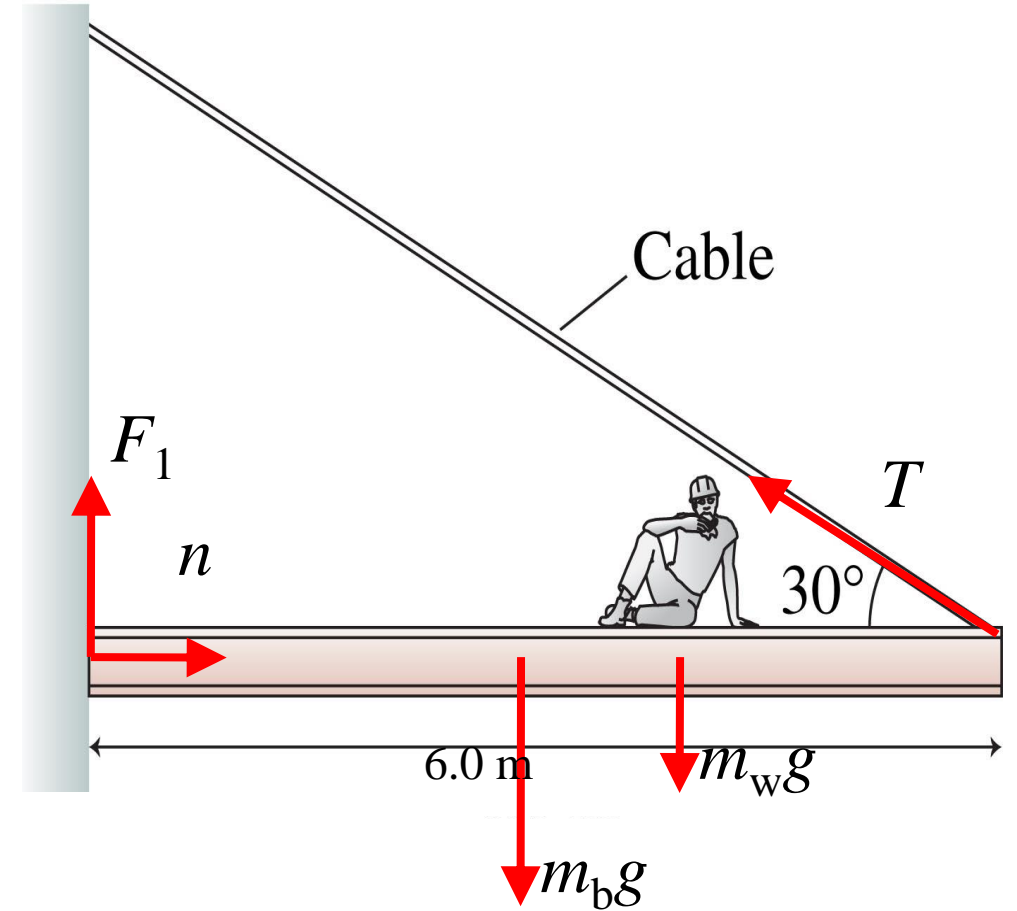
- **Today, Chapter 13:**
- General Periodic Oscillations
- Special case:  
Simple Harmonic Motion



## Learning Catalytics Question 1

- A construction worker of mass  $m_w$  sits 2.0 m from the end of a steel beam of mass  $m_b$ , as shown.
- The tension in the Cable is  $T$
- The wall exerts a normal force,  $n$  on the beam, and an upward force,  $F_1$ .
- Define  $+x =$  to the right,  $+y =$  up, and the pivot is the point where the beam touches the wall.
- What is the normal force,  $n$ ?

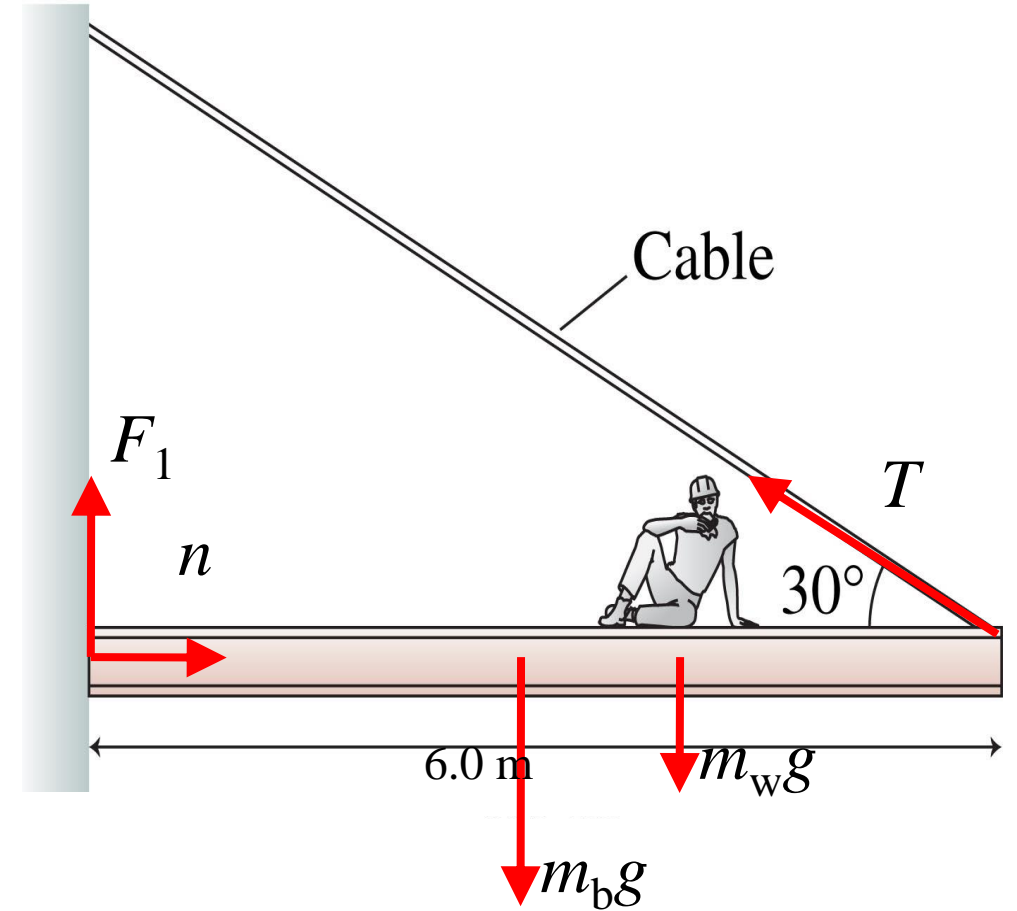
- A.
- B.
- C.
- D.
- E.



## Learning Catalytics Question 2

- A construction worker of mass  $m_w$  sits 2.0 m from the end of a steel beam of mass  $m_b$ , as shown.
- The tension in the Cable is  $T$
- The wall exerts a normal force,  $n$  on the beam, and an upward force,  $F_1$ .
- Define  $+x =$  to the right,  $+y =$  up, and the pivot is the point where the beam touches the wall.
- What is the force,  $F_1$ ?

- A.
- B.
- C.
- D.
- E.



# Bonus Point for Over 65% Course Evaluation Response Rate

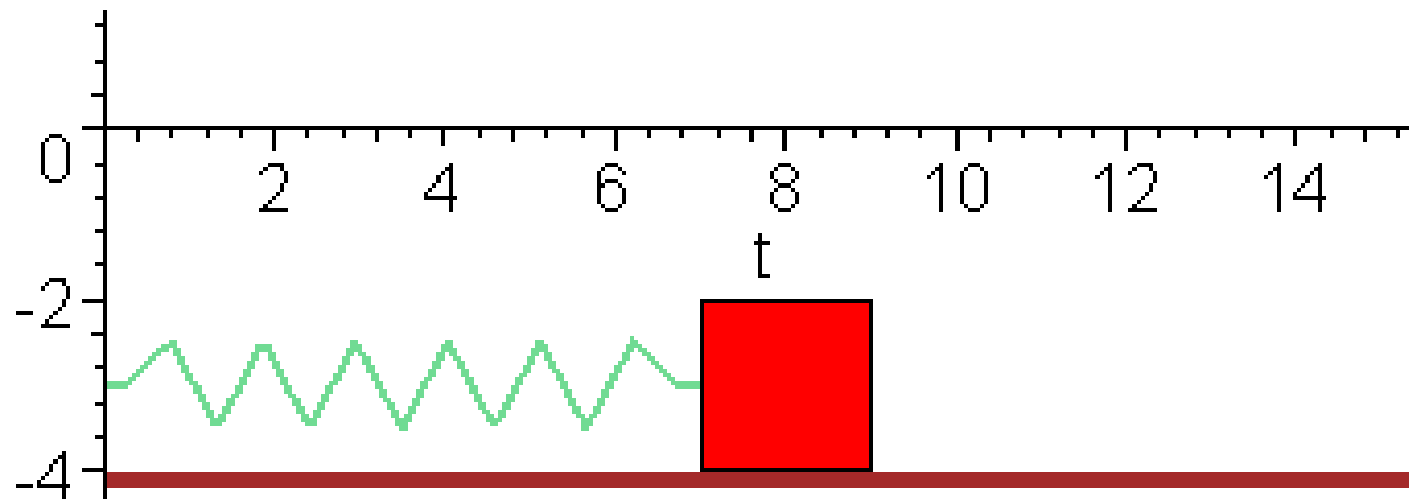
- An essential component of our commitment to teaching excellence is the regular evaluation of courses by students.
- On Nov. 24 you were sent an email by [course.evaluations@utoronto.ca](mailto:course.evaluations@utoronto.ca) to evaluate PHY131H1F.
- It only takes 10 or 15 minutes to answer the questions and enter your typed thoughts about the course.
- Your answers and thoughts are **anonymous**, but are very important to me and Brian.
- I promise you that when the results become available to us in January, Brian and I will **read** every comment and scrutinize the responses to see if it can help us improve the course or my teaching in the future.

# Bonus Point for Over 65% Course Evaluation Response Rate

- The end of the evaluation period for this semester is Thursday December 7 at 11:59PM.
- If, by the end of the course evaluation period, at least 65.00% of the students enrolled in this course have completed the course evaluations, then **every student in the course will have 1% bonus added to their final course mark.**
- If fewer than 65.00% of students complete the course evaluations by the deadline, then **no bonus point will be added for any student.**
- Results so far (as of \_\_\_\_\_ today):
- **Invited:** \_\_\_\_\_ students
- **Responded:** \_\_\_\_\_ students
- **Response Rate:** \_\_\_\_\_%

# Last day I asked

- A spring with a mass attached to it is stretched and released. When the spring returns to equilibrium, is the mass moving?
- Answer: Yes! It is not **accelerating**, but it is **moving** at that moment. Inertia then carries it past equilibrium to the other side. After passing equilibrium, the acceleration is opposite the velocity, so it slows down, eventually turning around.



# Period, frequency, angular frequency

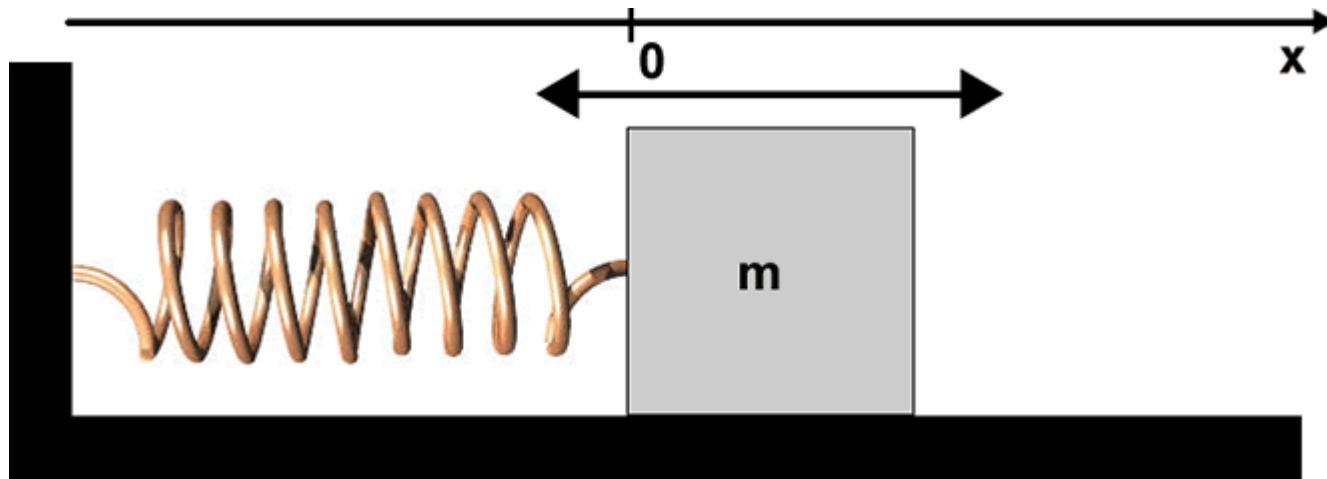
- The time to complete one full cycle, or one oscillation, is called the period,  $T$ .
- The frequency,  $f$ , is the number of cycles per second. Frequency and period are related by

$$f = \frac{1}{T} \quad \text{or} \quad T = \frac{1}{f}$$

- The oscillation frequency  $f$  is measured in cycles per second, or Hertz.
- We may also define an angular frequency  $\omega$  in radians per second, to describe the oscillation.

$$\omega \text{ (in rad/s)} = \frac{2\pi}{T} = 2\pi f \text{ (in Hz)}$$

# The Spring-Mass System



The force exerted on the mass by the spring:

$$F = -k x \quad (\text{Hooke's Law})$$

$$F = m a \quad (\text{Newton's Second Law})$$

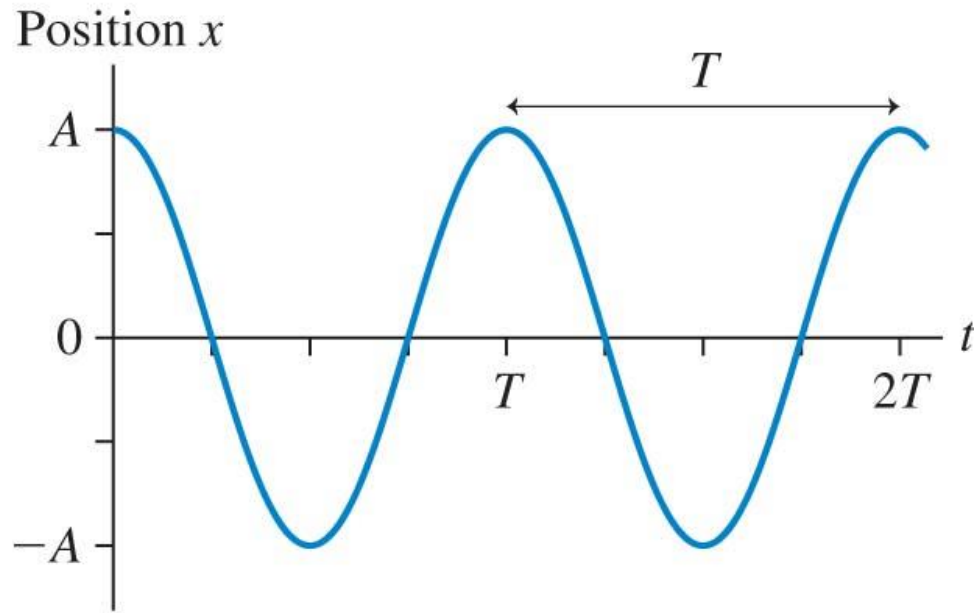
Combine to form a differential equation:

$$a = \frac{d^2 x}{dt^2} = -\frac{k}{m} x$$

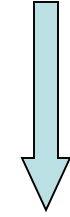


## Solving S.H.M.

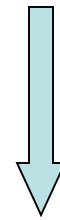
$$a = \frac{d^2 x}{dt^2} = -\frac{k}{m} x$$



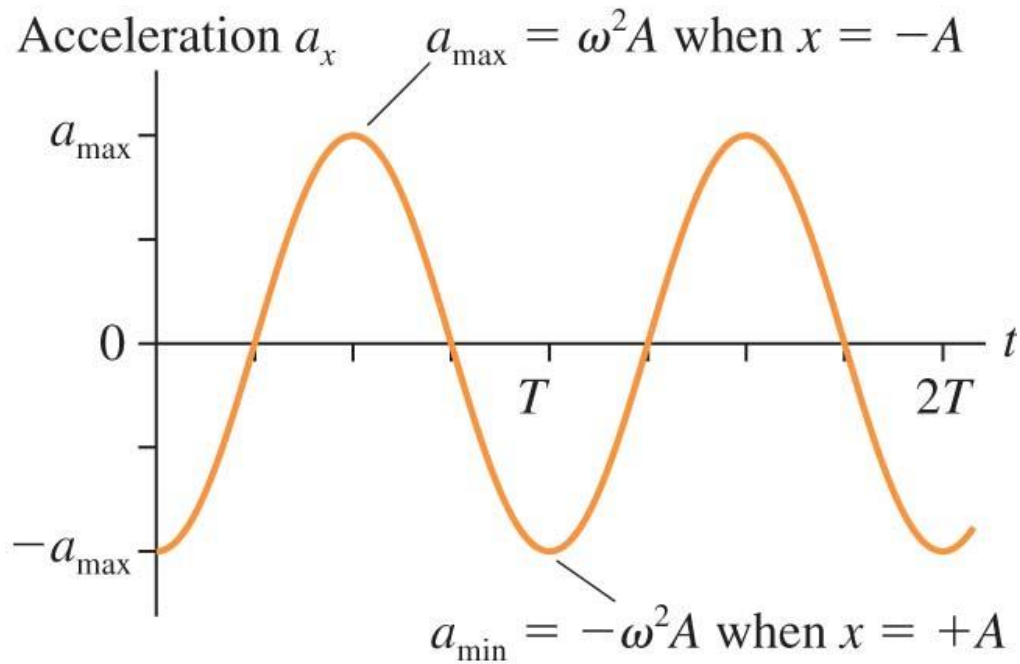
$$F_s = -kx$$



$$a = \frac{F_{Net}}{m}$$



$$a_x = -\frac{k}{m}x$$



# Simple Harmonic Motion

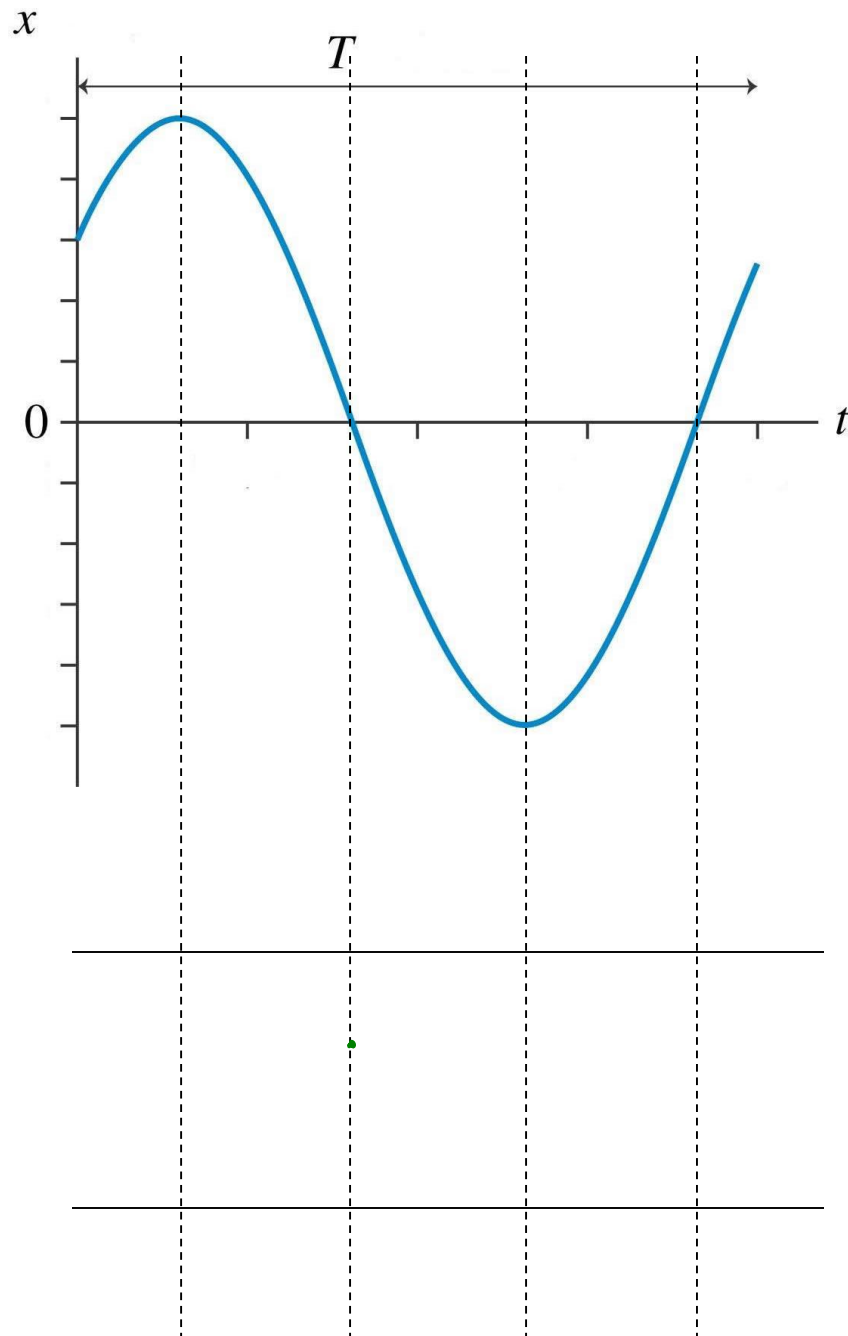
If the initial position of an object in SHM is not  $A$ , then we may still use the cosine function, with a phase constant  $\phi_0$  measured in radians.

# Simple Harmonic Motion (SHM)

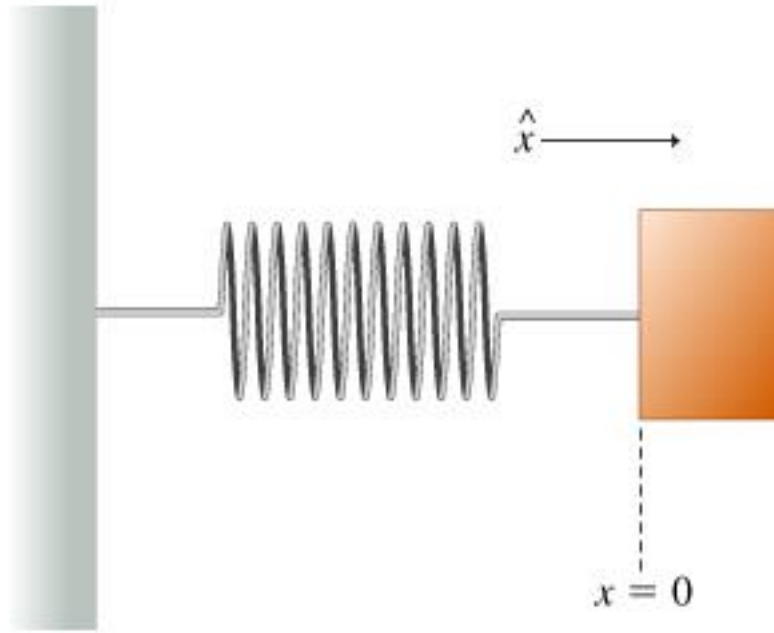
$$x = A \cos(\omega t + \phi_0)$$

$$v = \frac{dx}{dt} = -A\omega \sin(\omega t + \phi_0)$$

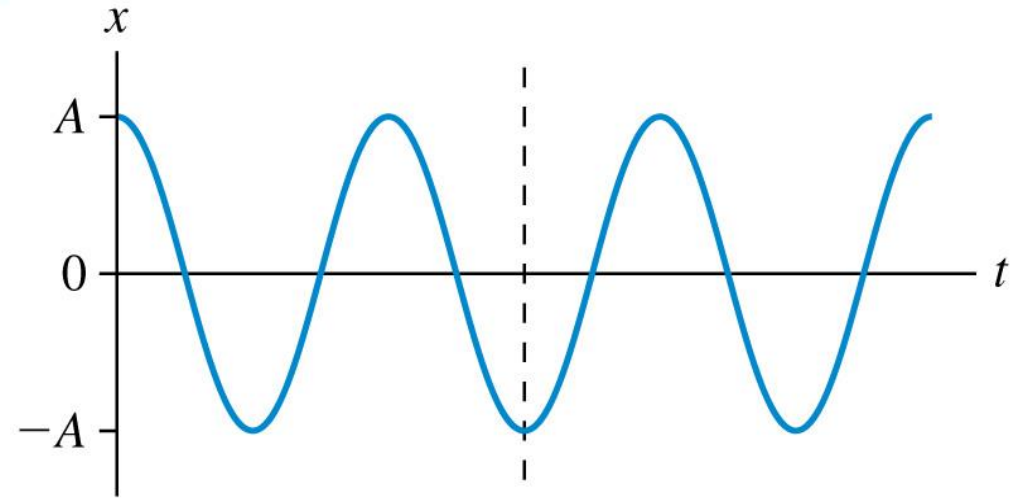
$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = -A\omega^2 \cos(\omega t + \phi_0)$$



Learning  
Catalytics  
Question 3

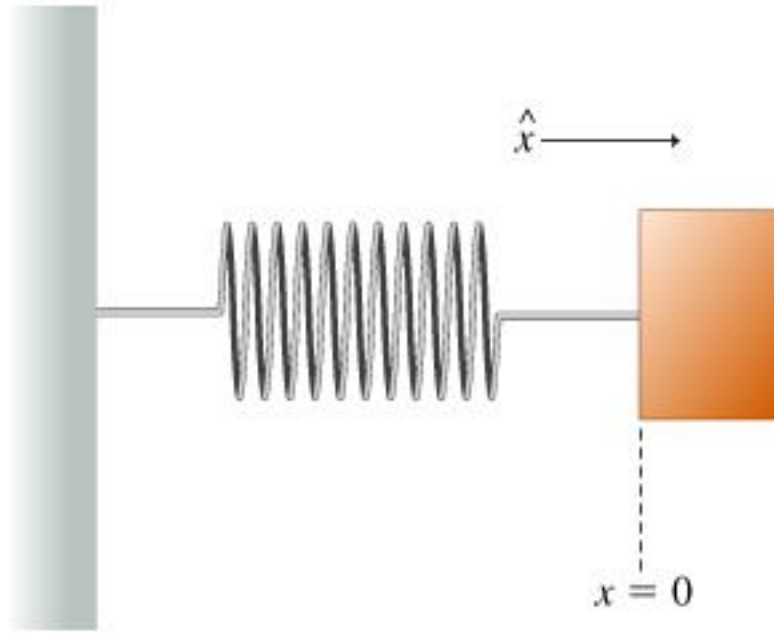


This is the position graph of a mass on a spring. What can you say about the velocity and the force at the instant indicated by the dotted line?

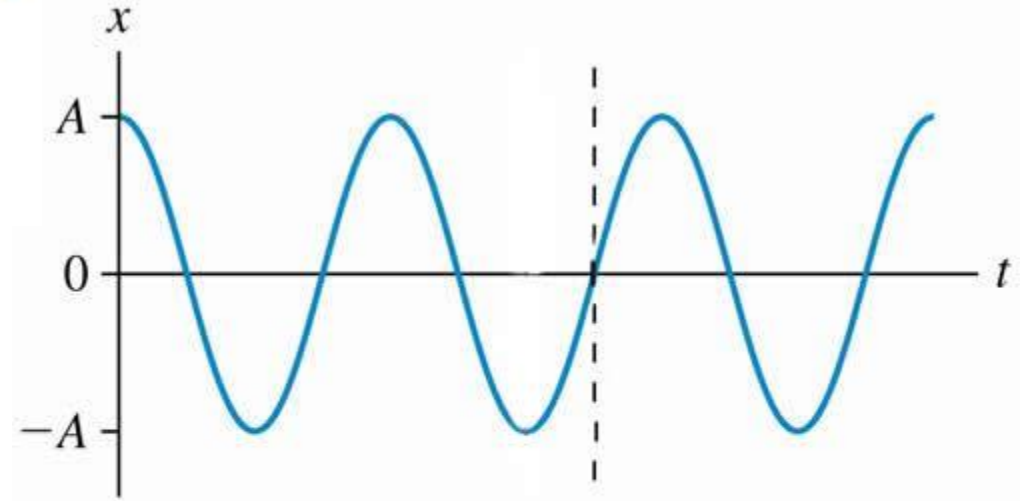


- A.
- B.
- C.
- D.
- E.

Learning  
Catalytics  
Question 4



This is the position graph of a mass on a spring. What can you say about the velocity and the force at the instant indicated by the dotted line?

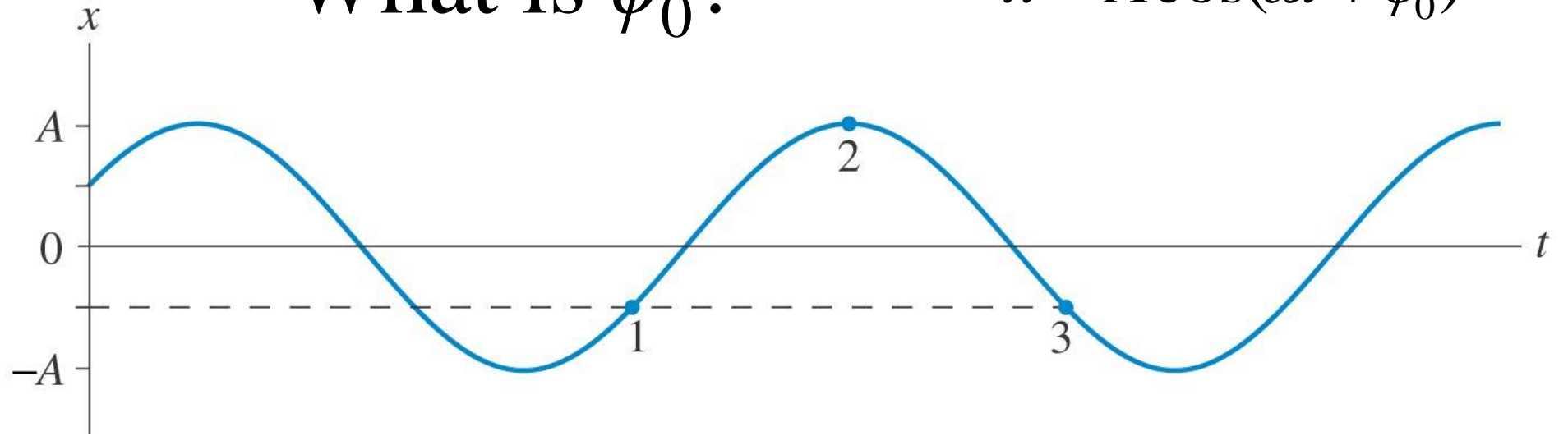


- A.
- B.
- C.
- D.
- E.

Learning  
Catalytics  
Question 5

What is  $\phi_0$ ?

$$x = A \cos(\omega t + \phi_0)$$



- A.
- B.
- C.
- D.
- E.

# S.H.M. notes.

- The frequency,  $f$ , is set by the properties of the system. In the case of a mass  $m$  attached to a spring of spring-constant  $k$ , the frequency is always

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

- $A$  and  $\phi_0$  are set by the initial conditions:  $x_0$  (initial position) and  $v_0$  (initial velocity).
- $A$  turns out to be related to the total energy of the spring oscillator system:  $E = \frac{1}{2} k A^2$ .

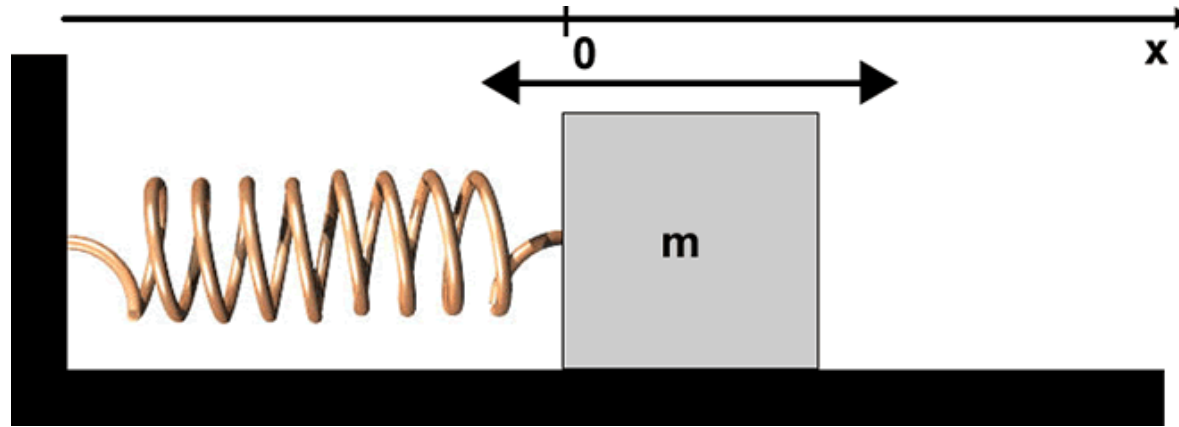


## Learning Catalytics Question 6

Which of the following quantities in the description of **simple harmonic motion** is *not* determined by the initial position and velocity of the mass?

- A.
- B.
- C.
- D.
- E.

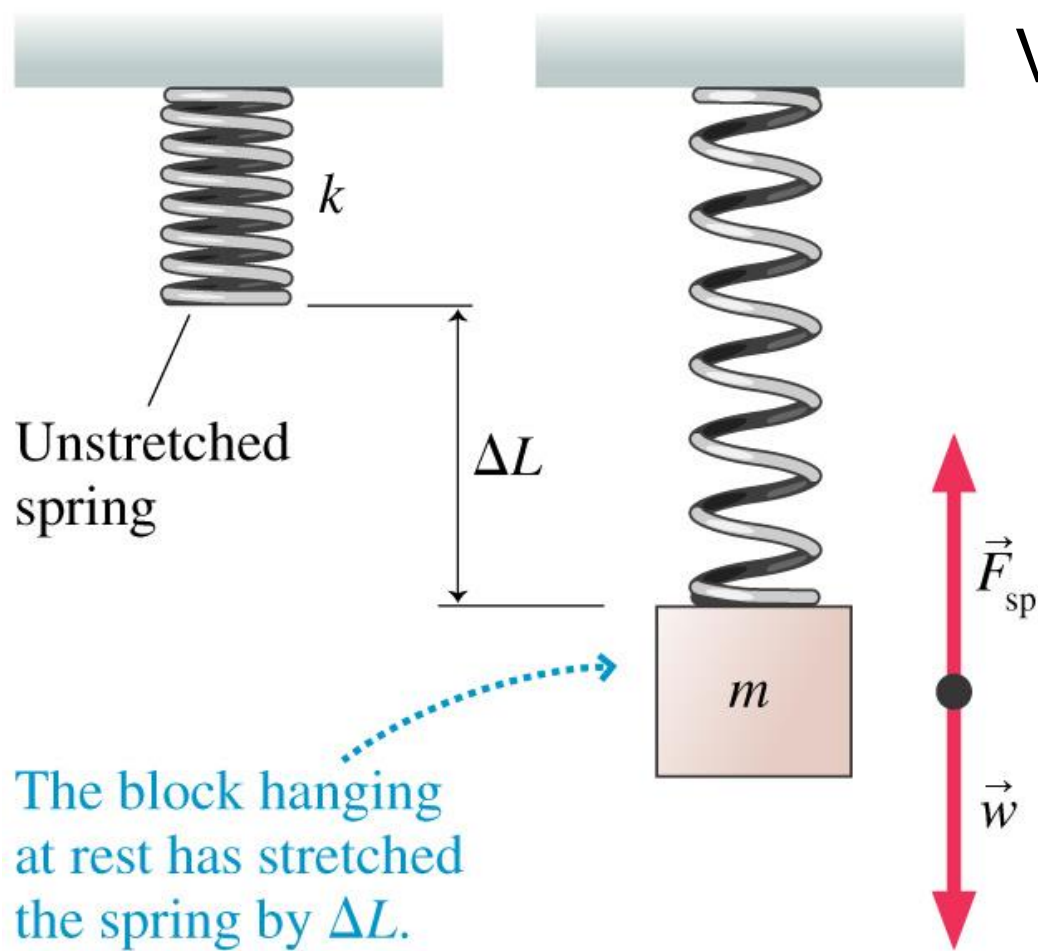
Learning  
Catalytics  
Question 7



**A mass is oscillating on a spring in S.H.M. When it passes through its equilibrium point, an external “kick” suddenly decreases its speed, but then it continues to oscillate. As a result of this slowing, the frequency of the oscillation**

- A.
- B.
- C.

# Vertical Mass on a Spring



Unstretched spring

$\Delta L$

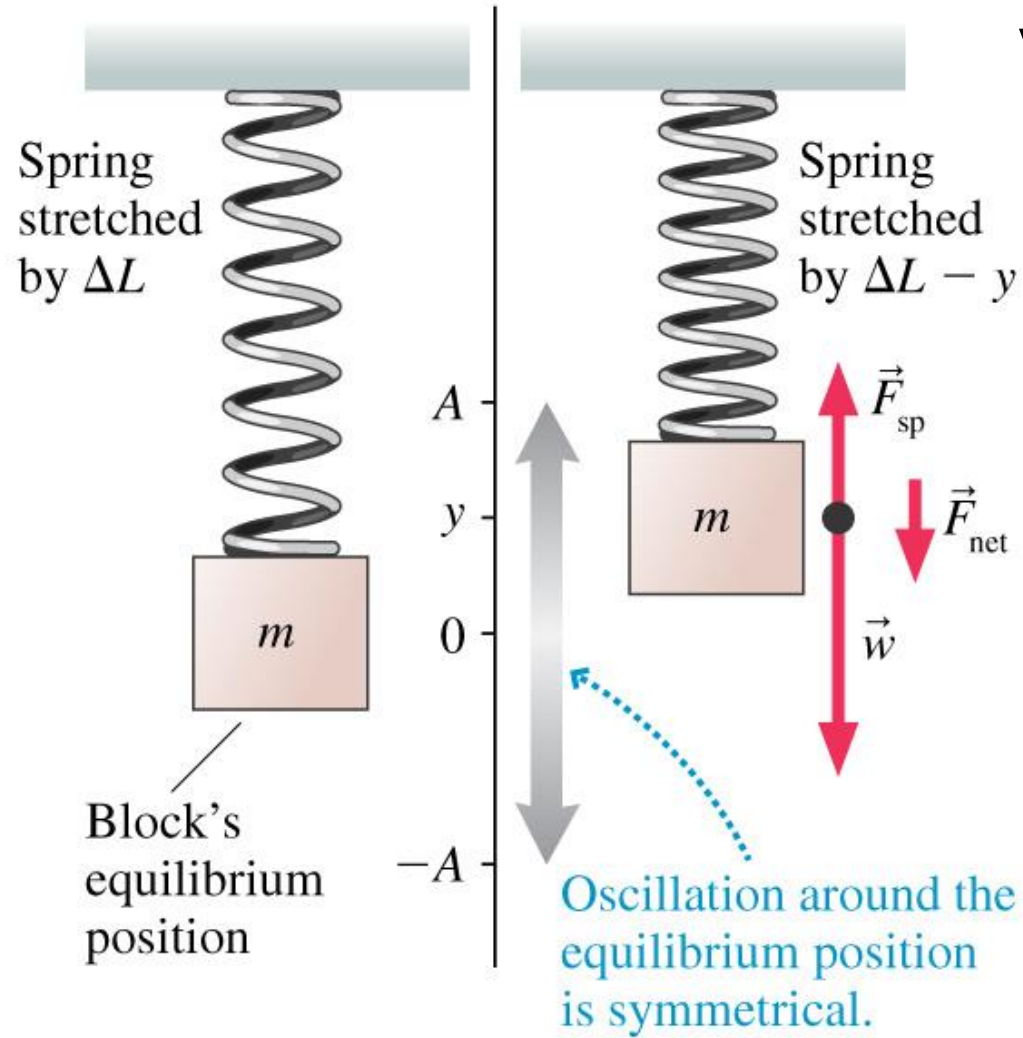
$m$

$\vec{F}_{sp}$

$\vec{W}$

The block hanging at rest has stretched the spring by  $\Delta L$ .

# Vertical Mass on a Spring



# Before Class 21 on Wednesday

- Please finish reading Chapter 13 on Oscillations, and/or watch the Preclass Video 21.



- Problem Set 9 on Chapters 10 and 11 is due tonight at 11:59pm.
- Something to think about over the weekend: If you double the mass of a mass on a spring, how does this change the frequency? If you double the mass of a swinging pendulum, how does this change the frequency? What is the difference here?

