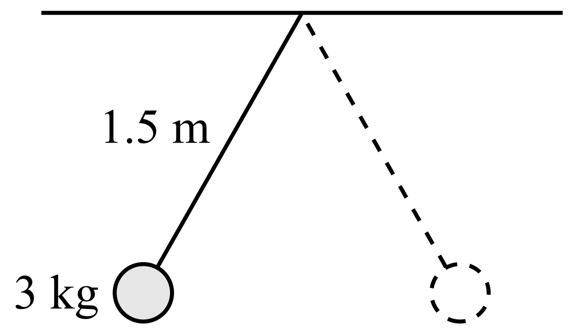
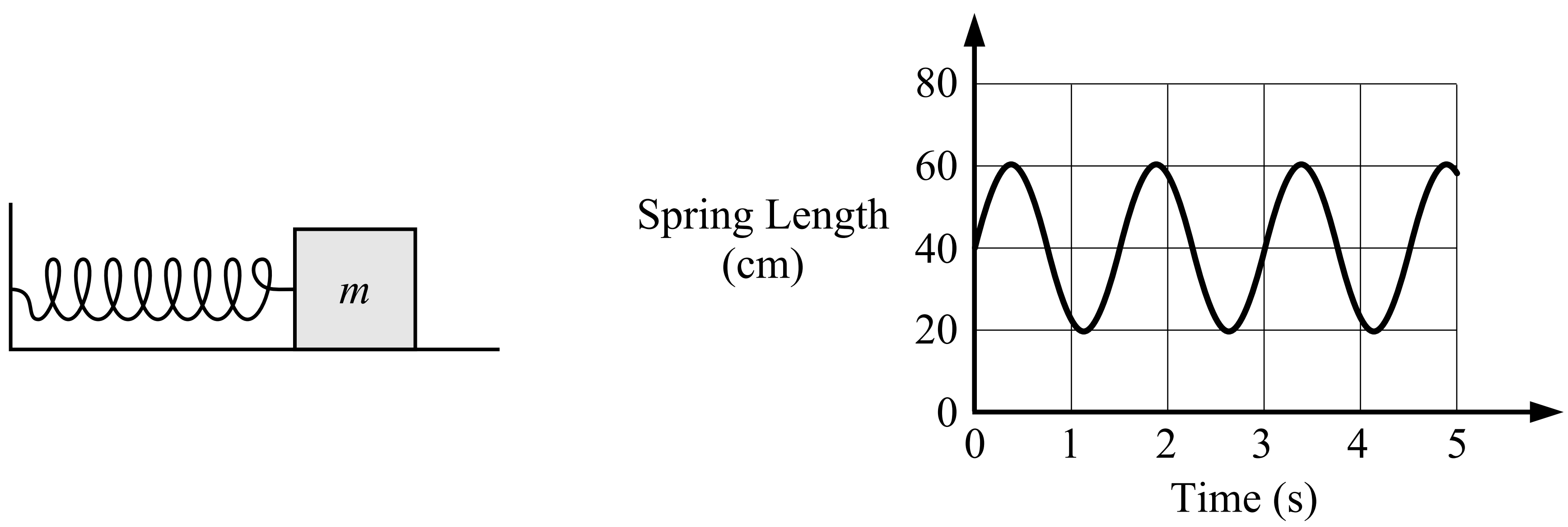
# SIMPLE HARMONIC MOTION



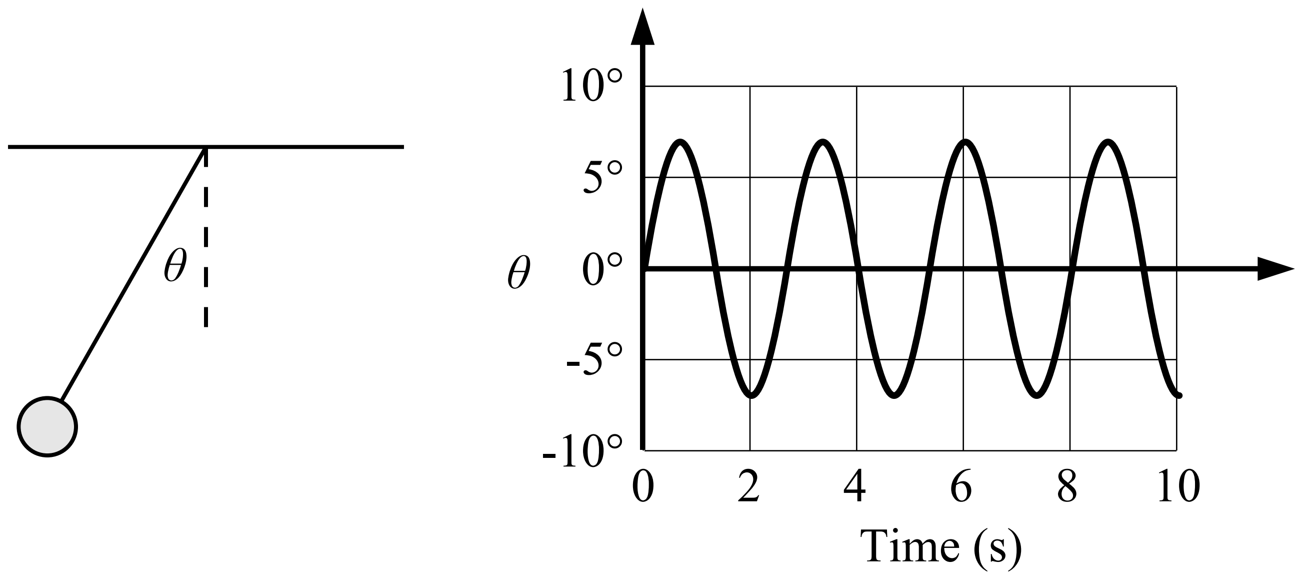

1. A 3 kg mass is attached to a 1.5 m long string with negligible mass as shown in the figure above. The mass is released from rest at the position shown. The time it takes for the mass to swing across to the other side, where the mass is at the same height, is most nearly

   (A) 0.2 s
   (B) 1.2 s
   (C) 8.1 s
   (D) 2.4 s



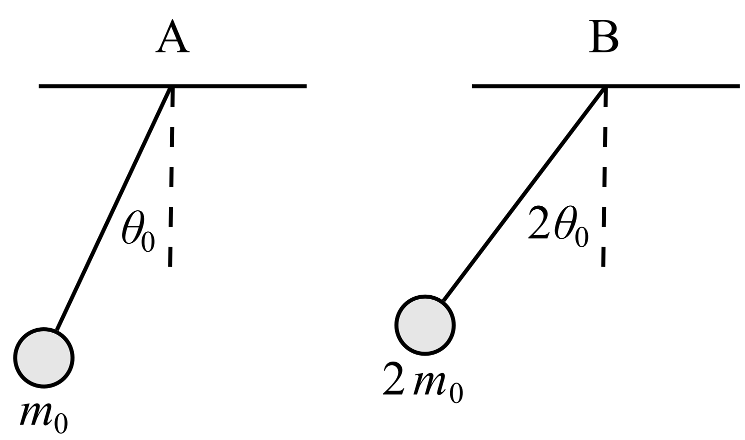

2. A block is attached to a spring with a spring constant of 50 N/m as shown in the figure above. The block is oscillating back and forth on a surface with negligible friction and the length of the spring over time is shown in the graph above. The mass of the block is most nearly

   (A) 112.5 kg
   (B) 11.4 kg
   (C) 2.8 kg
   (D) 0.7 kg




3. A graph of the angle between a pendulum and the vertical is shown in the figure above. The frequency of the pendulum is most nearly

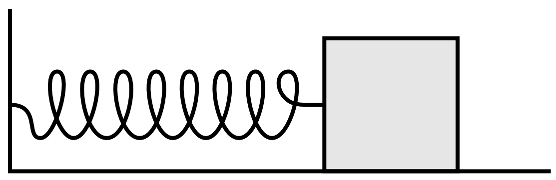
(A) 0.25 Hz
(B) 0.38 Hz
(C) 1 Hz
(D) 2.67 Hz

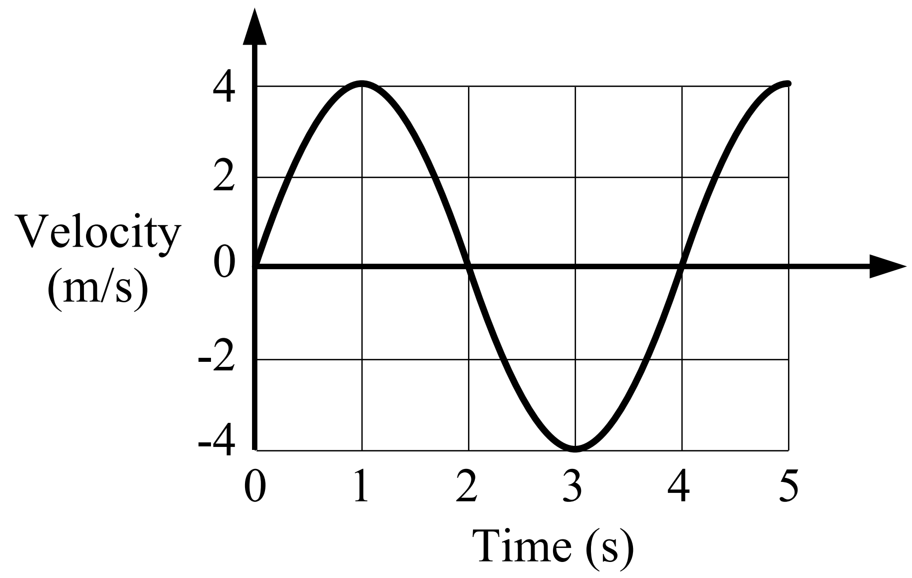



Note: Figure not drawn to scale.

4. Two spheres are attached to identical strings and released from rest at the angles shown in the figure above. Which of the following correctly relates the periods of pendulum A and pendulum B?

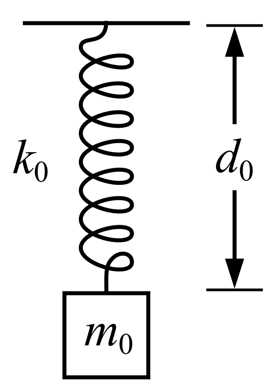
(A) $T_B = 4T_A$
(B) $T_B = 2T_A$
(C) $T_B = T_A$
(D) $T_B = T_A/2$





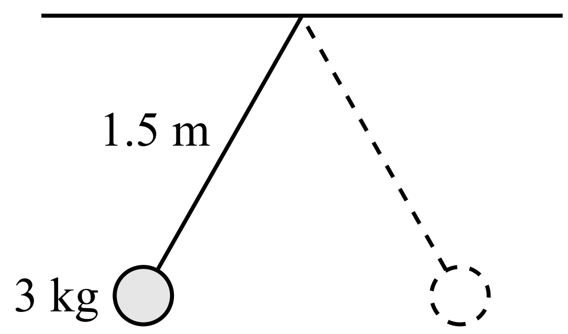

5. A mass is attached to a spring and moves back and forth on a surface with negligible friction. A graph of the motion of the block is shown in the graph above. At which of the following times is the magnitude of the spring force on the block the greatest?

    (A) 1 s
    (B) 3 s
    (C) 1.5 s
    (D) 2 s




6. A block of mass $m_0$ is suspended from the ceiling by a spring with a spring constant of $k_0$. The block is pulled down to a distance of $d_0$ from the ceiling and released from rest, and the block oscillates up and down. Which of the following changes would increase the frequency of the oscillation?

    (A) Replace the block with a different block of mass $m_0/2$
    (B) Pull the block down to a distance of $2d_0$
    (C) Replace the spring with a different spring with a spring constant of $k_0/2$ and the same original length
    (D) Pull the block down to a distance of $d_0/2$




1. A 3 kg mass is attached to a 1.5 m long string with negligible mass as shown in the figure above. The mass is released from rest at the position shown. The time it takes for the mass to swing across to the other side, where the mass is at the same height, is most nearly

   (A) 0.2 s
   (B) 1.2 s
   (C) 8.1 s
   (D) 2.4 s

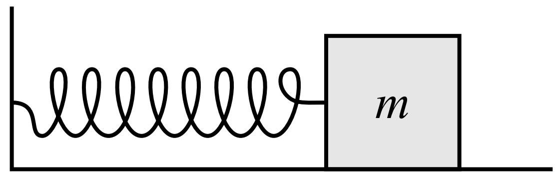
A Incorrect
This answer excludes the $2\pi$ in the equation for the period of the pendulum.

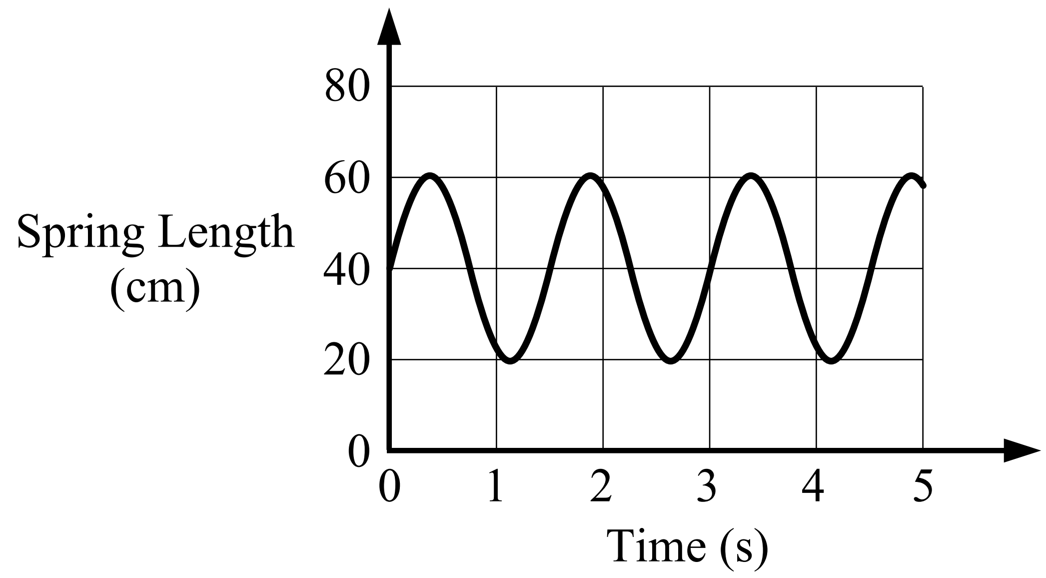
**B Correct**
The time it takes to swing from one side to the other is half of the period of the pendulum's motion, which is given by the equation below. The period does not depend on the mass.

$$T_p = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{1.5\text{ m}}{g}} = 2.4\text{ s} \qquad t = \frac{2.4\text{ s}}{2} = 1.2\text{ s}$$

C Incorrect
This answer switches $L$ and $g$ in the equation for the period of the pendulum.

D Incorrect
This answer is the period of the pendulum. The question is asking for half of the period.




2. A block is attached to a spring with a spring constant of 50 N/m as shown in the figure above. The block is oscillating back and forth on a surface with negligible friction and the length of the spring over time is shown in the graph above. The mass of the block is most nearly

(A) 112.5 kg

(B) 11.4 kg

(C) 2.8 kg

(D) 0.7 kg

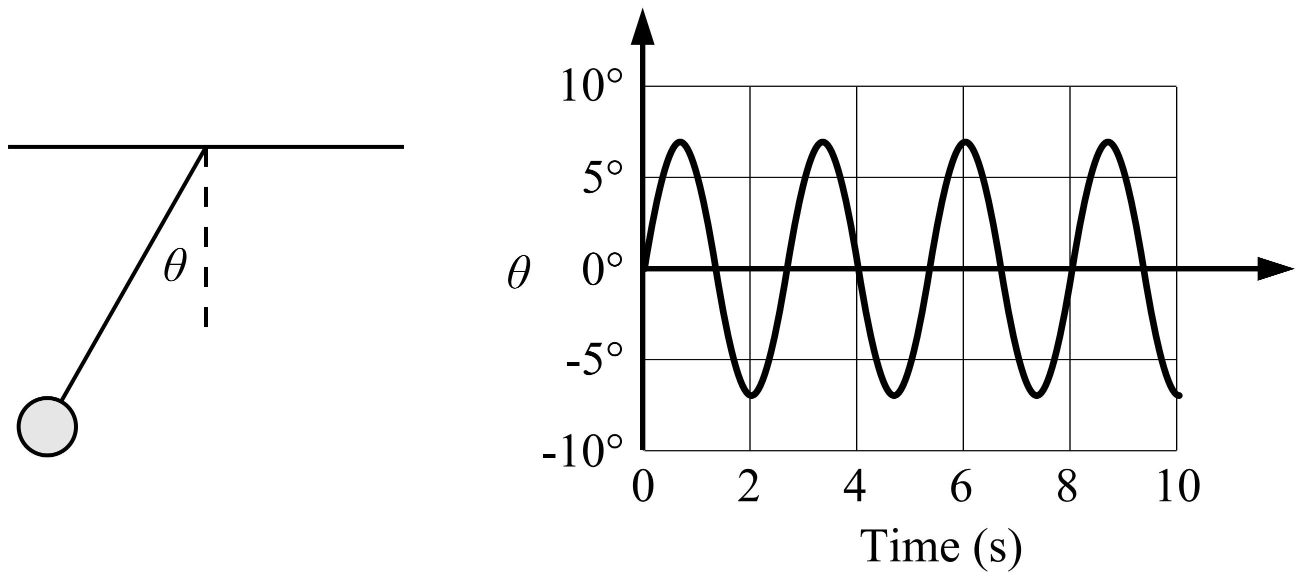
A Incorrect
This answer excludes the $2\pi$ in the equation for the period of the oscillation.

B Incorrect
This answer incorrectly uses 3 seconds for the period of the oscillation.

**C Correct**
The period of the mass-spring oscillation depends on the mass and the spring constant. The period of the oscillation is 1.5 seconds which can be found from the graph (there is 1.5 seconds per cycle or 3 seconds for 2 cycles).

$$T_{sp} = 2\pi\sqrt{\frac{m}{k}} \qquad 1.5\text{ s} = 2\pi\sqrt{\frac{m}{50\text{ N/m}}} \qquad m = 2.8\text{ kg}$$

D Incorrect
This answer incorrectly uses 0.75 seconds for the period of the oscillation.

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(A) 0.25 Hz
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(C) 1 Hz
(D) 2.67 Hz

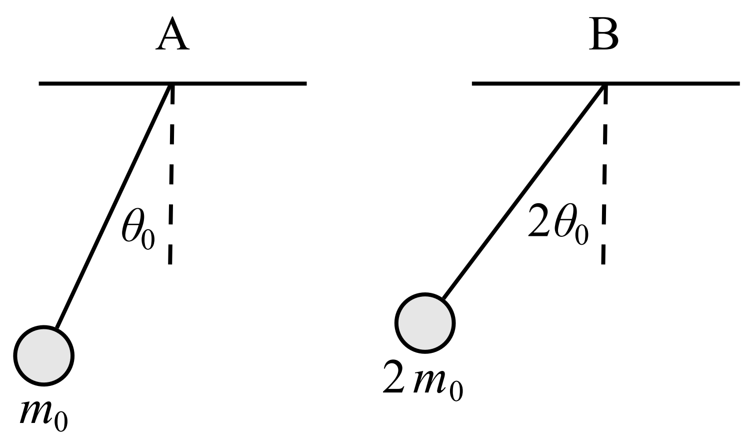
A Incorrect

**B Correct**
The frequency of the pendulum is the number of oscillations per second, or the inverse of the period. There are 1.5 cycles (wavelengths) in 4 seconds or 3 cycles in 8 seconds.

$$f = \frac{3 \text{ cycles}}{8 \text{ s}} = 0.38 \text{ Hz}$$

C Incorrect

D Incorrect
This answer is the period (2.67 s) with the unit of Hz.




<u>Note</u>: Figure not drawn to scale.

4. Two spheres are attached to identical strings and released from rest at the angles shown in the figure above. Which of the following correctly relates the periods of pendulum A and pendulum B?

(A) $T_B = 4T_A$
(B) $T_B = 2T_A$
(C) $T_B = T_A$
(D) $T_B = T_A/2$

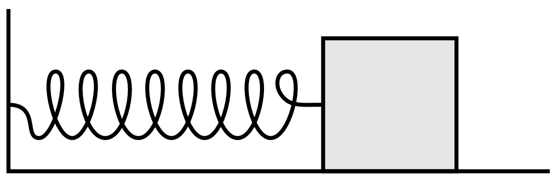
A Incorrect

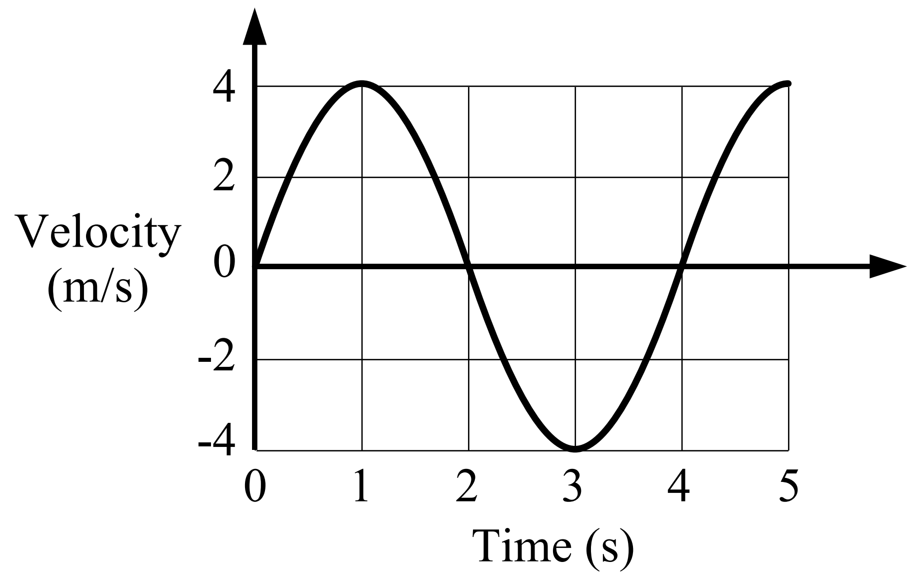
B Incorrect

C **Correct**
The period of a pendulum depends on the length of the pendulum and the acceleration due to gravity $g$. The pendulums have identical strings with the same length so the pendulums have the same period. The period does not depend on the mass or the amplitude (maximum height or angle).

$$T_p = 2\pi\sqrt{\frac{L}{g}}$$

D Incorrect



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(A) 1 s

(B) 3 s

(C) 1.5 s

(D) 2 s

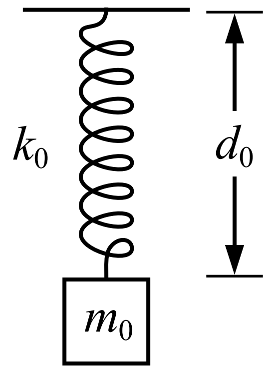
A Incorrect

B Incorrect

C Incorrect

**D Correct**

The magnitude of the spring force on the block is greatest when the block is at one of the position amplitudes and the spring displacement is at a maximum. The velocity of the block is zero when it is at an amplitude and the velocity is zero at 2 seconds. Also, the acceleration of the block will be at a maximum when the spring force (the only horizontal force) is at a maximum. Acceleration is the slope of the velocity-time graph and the magnitude of the slope is greatest at 2 seconds.

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(B) Pull the block down to a distance of $2d_0$

(C) Replace the spring with a different spring with a spring constant of $k_0/2$ and the same original length

(D) Pull the block down to a distance of $d_0/2$

**A Correct**

The equation for the period and frequency of a mass-spring oscillation is shown below. Decreasing the mass would increase the frequency of the oscillation.

$$f_{sp} = \frac{1}{T_{sp}} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

B Incorrect

The frequency of the oscillation is not related to the amplitude, so changing the original height of the block would not affect the frequency.

C Incorrect

Decreasing the spring constant would decrease the frequency of the oscillation.

D Incorrect

The frequency of the oscillation is not related to the amplitude, so changing the original height of the block would not affect the frequency.