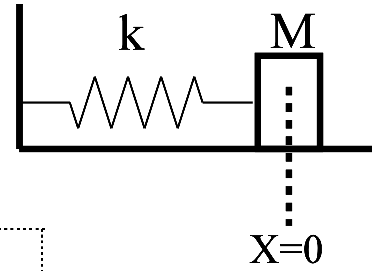
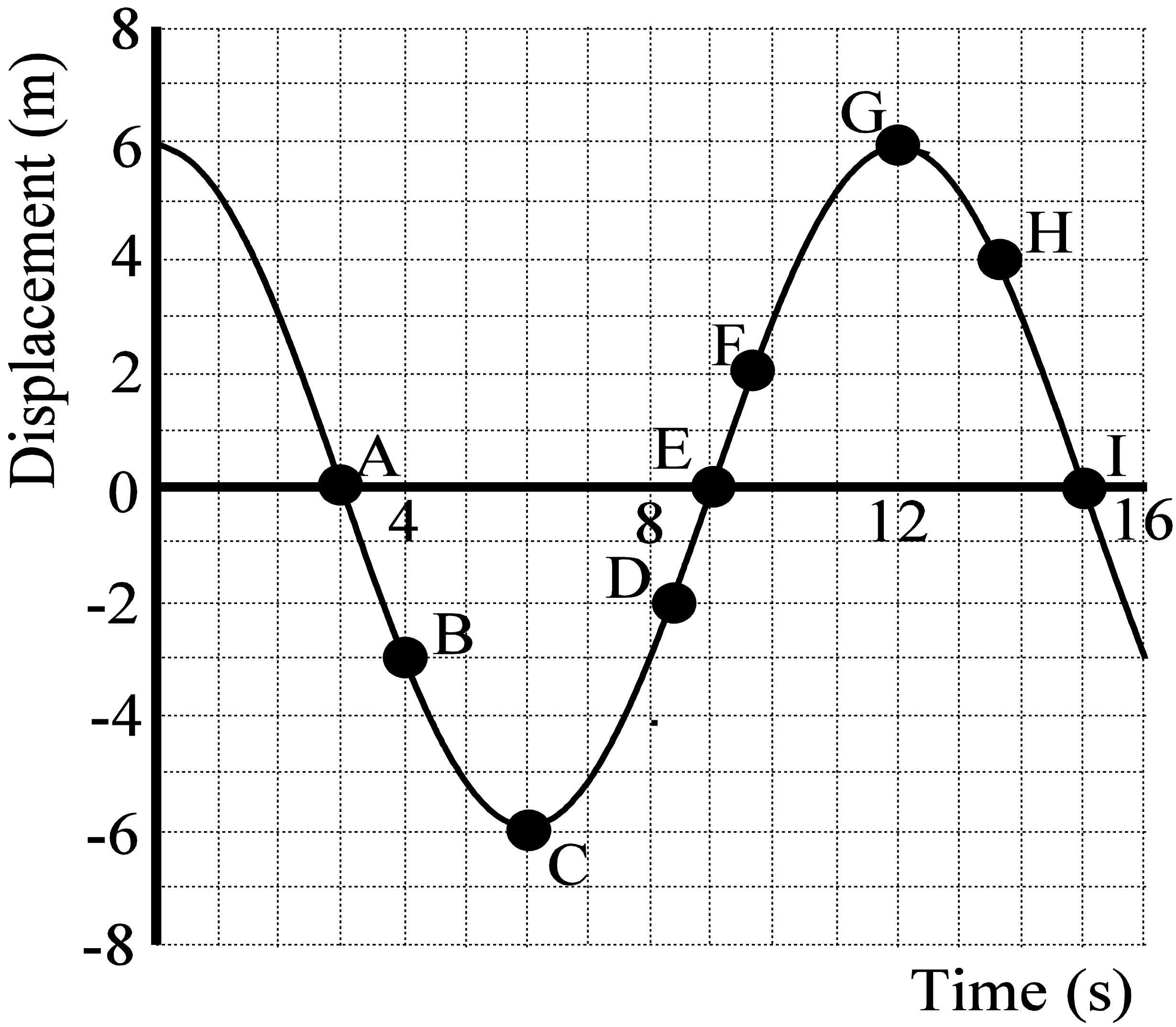
First Name:____________________ Last Name:________________________________

A cart attached to a spring is displaced from equilibrium and then released from rest. A graph of displacement in the $\hat{x}$ direction as a function of time for the cart is shown below. There is no friction. Nine points (A-I) are labeled on the graph. We will refer to them later. **EACH BOX IS 1 sec.**





1. Write the appropriate value (including units!):

   - Amplitude = ________________

   - Period = _________________

   - Angular frequency = ______________

2. Determine the mathematical expression for the displacement of the cart as a function of time. Make sure you substitute for everything you can.

3. Assume that the mass of the cart is m=10 kg. Find the spring constant k.

4. Rank, from most positive to zero to most negative the net force on the mass when it is at the locations shown in problem 1.

   Most positive   Most negative

   Explain your reasoning.

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5. At which point or points (A-I) is the cart experiencing a positive acceleration? Explain your reasoning.

6. At which point or points (A-I) is the **acceleration** nonzero and opposite in direction to the **displacement**? Explain your reasoning.

7. At which point or points (A-I) is the **velocity** nonzero and opposite in direction to the **acceleration**? Explain your reasoning.

8. At which point or points (A-I) does the potential energy have its maximum value? Explain your reasoning.

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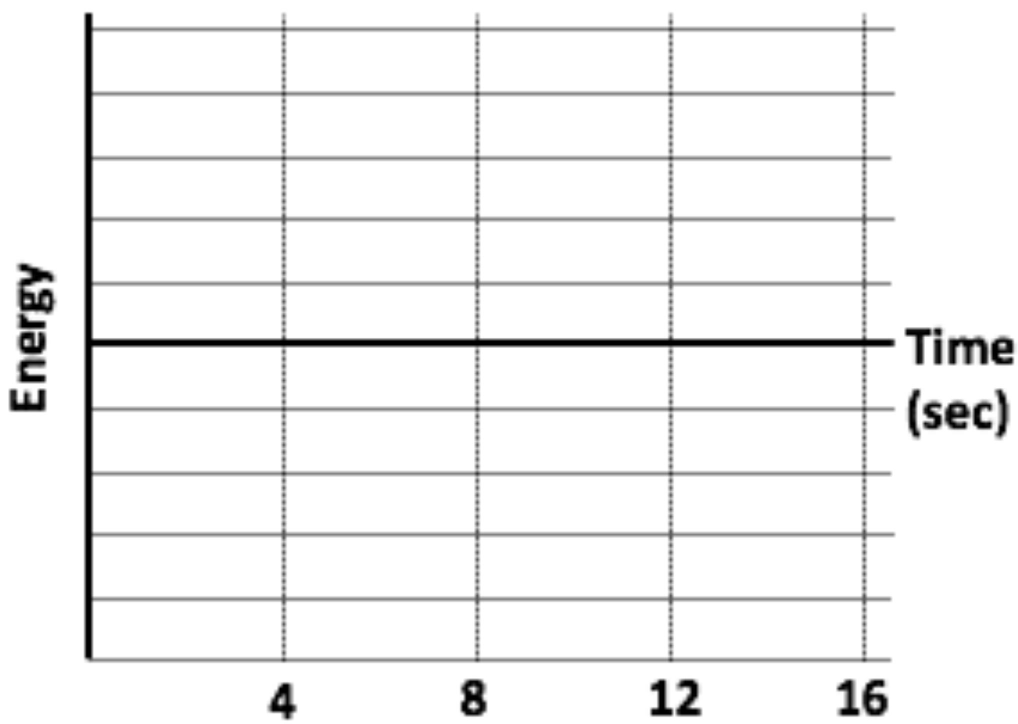
9. Write an expression for the maximum potential energy identified in question 8 in terms of the amplitude A, the frequency ω, and the mass m.

10. What is the kinetic energy of the system at the points at which the potential energy is maximal? Explain your reasoning, and use your answer to find an expression for the **total** mechanical energy of the system.

11. At which point or points (A-I) does the kinetic energy achieve its maximum value? What is the spring's potential energy at those points? What about the kinetic energy? Explain your answers.

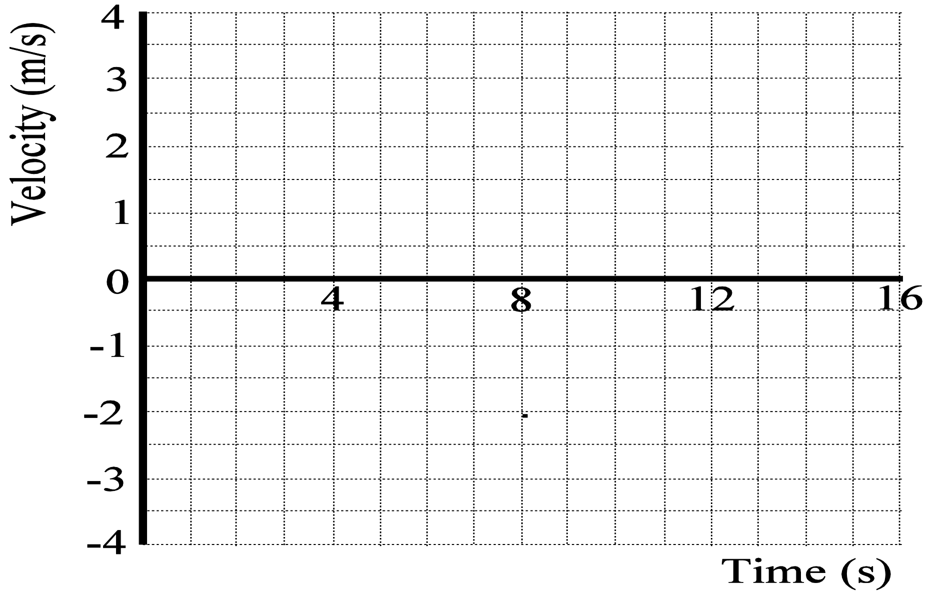
12. Use you answer from question 9 to find an expression for the maximum velocity of a simple harmonic oscillator.

13. Starting from point A, sketch how the both kinetic energy and the potential energy vary as a function of time, i.e. you must show both K(t) and U(t).



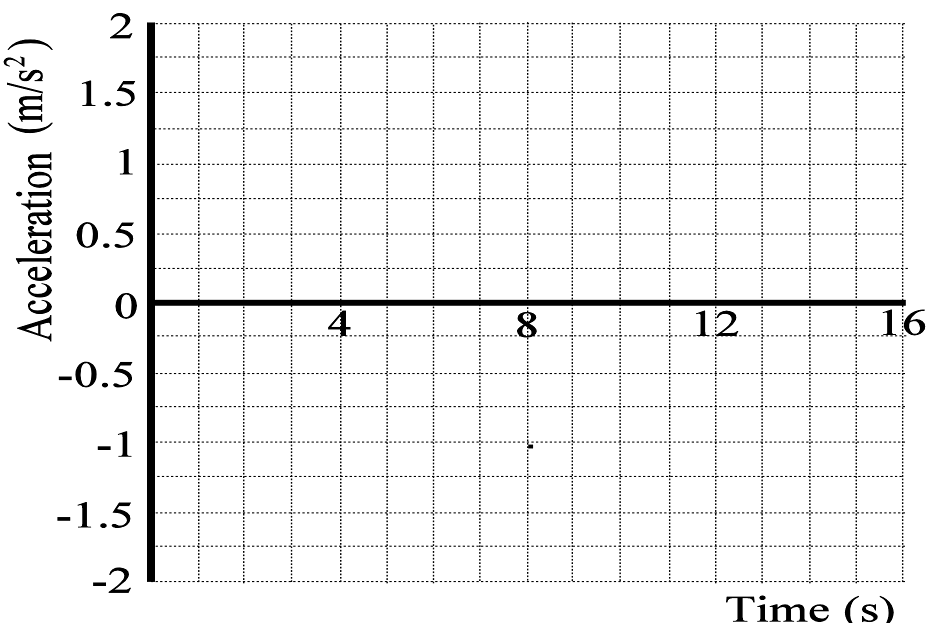
14. Starting from your answer in question 2, determine the mathematical expression for the velocity of the cart as a function of time.

15. Sketch a graph of the velocity of the cart as a function of time.

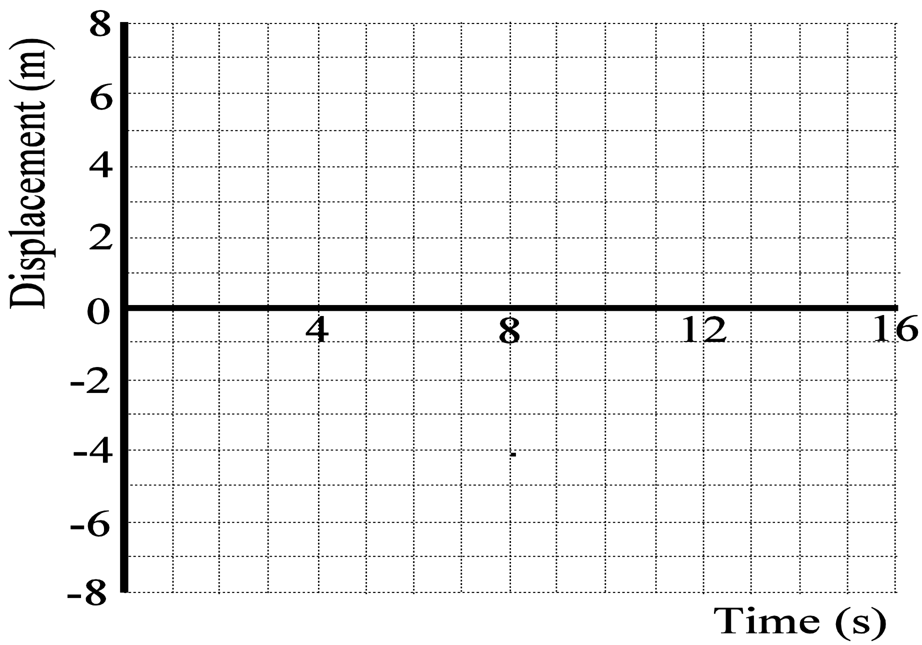


16. Starting from your answer in question 2, determine the mathematical expression for the acceleration of the cart as a function of time.

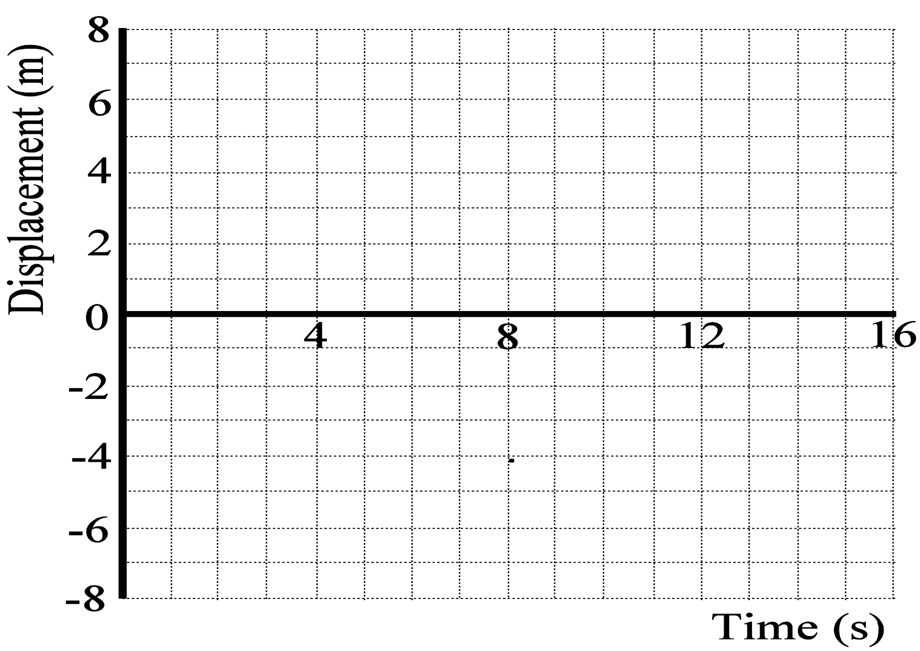
17. Sketch a graph of the acceleration of the cart as a function of time.



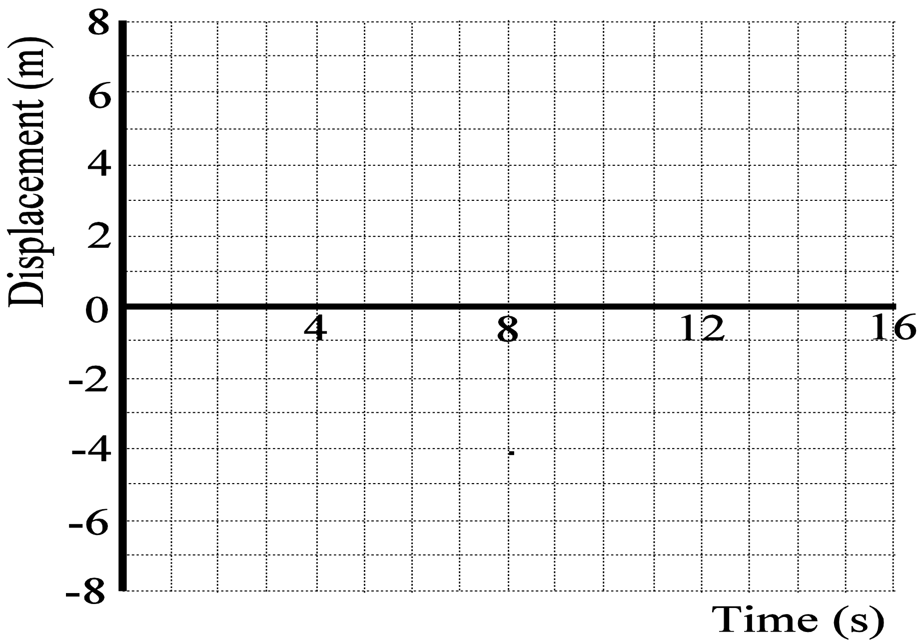
18. Imagine that the mass of the cart became four times larger. It is still released from rest at the same position. Sketch a graph of the displacement of the cart as a function of time. Explain your reasoning.



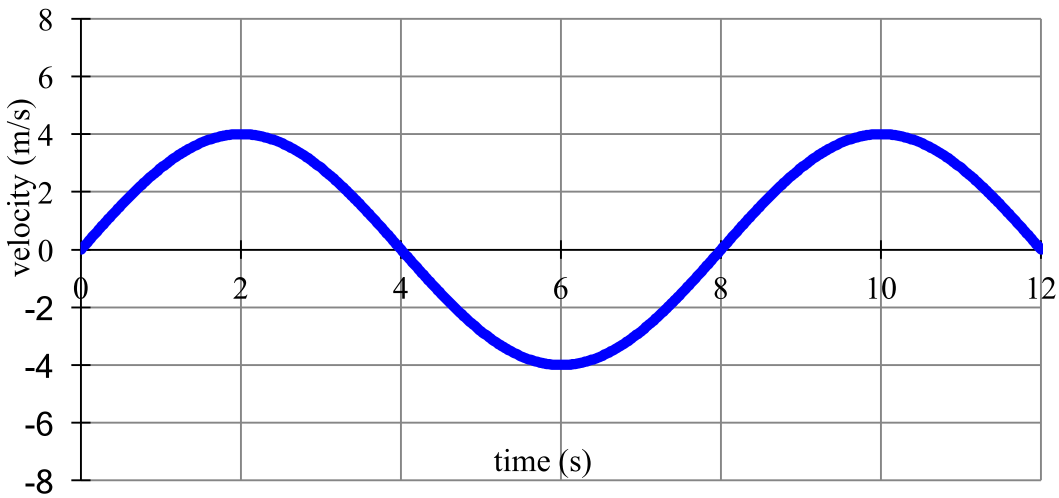
19. Imagine that the spring constant became 2.25 times larger. It is still released from rest at the same position. Sketch a graph of the displacement of the cart as a function of time. Explain your reasoning.

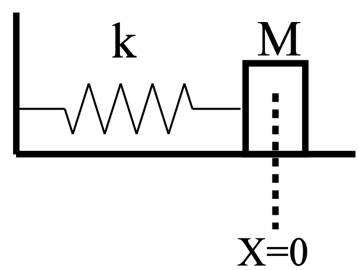


20. Imagine that the cart was pulled two-thirds as far from the spring's equilibrium point before it was released from rest. Sketch a graph of the displacement of the cart as a function of time. Explain your reasoning.



A cart attached to a spring is displaced from equilibrium and then released from rest. A graph of the cart's velocity as a function of time is shown below. There is no friction.



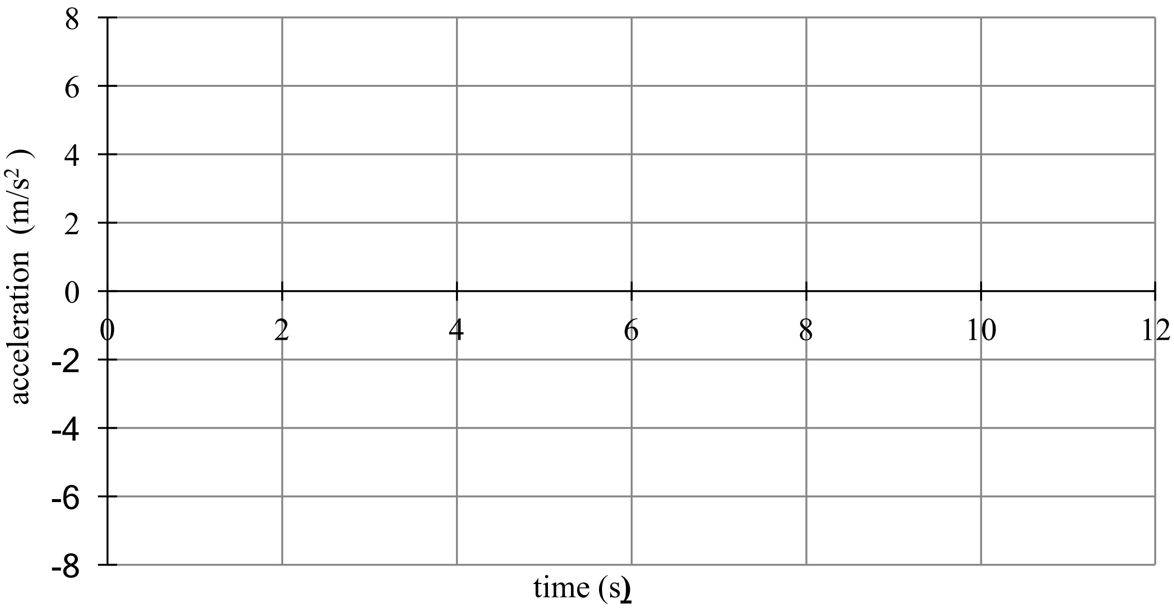


21. What are the period, the frequency and the angular frequency of the cart's motion?

22. Left or right: In which direction was the cart displaced from equilibrium before it was released? Explain your reasoning.

23. Determine the mathematical expression for the velocity of the cart as a function of time. Make sure you substitute for everything you can.

24. Sketch a graph of the acceleration of the cart as a function of time.



25. Sketch a graph of the displacement of the cart as a function of time. You may assume that the average displacement over one cycle is zero.