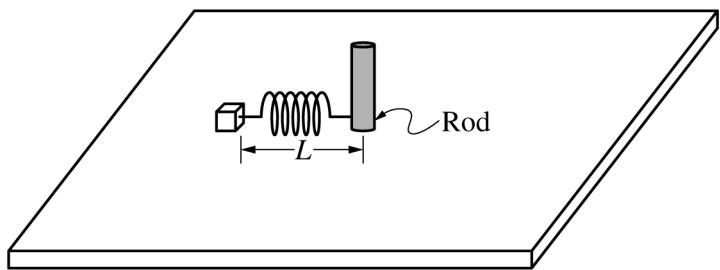


Begin your response to **QUESTION 3** on this page.



3. (12 points, suggested time 25 minutes)

A small block of mass m_0 is attached to the end of a spring of spring constant k_0 that is attached to a rod on a horizontal table. The rod is attached to a motor so that the rod can rotate at various speeds about its axis. When the rod is not rotating, the block is at rest and the spring is at its unstretched length L , as shown. All frictional forces are negligible.

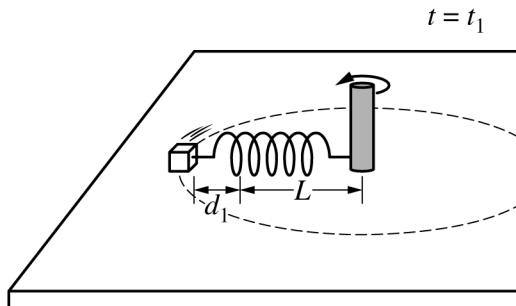


Figure 1

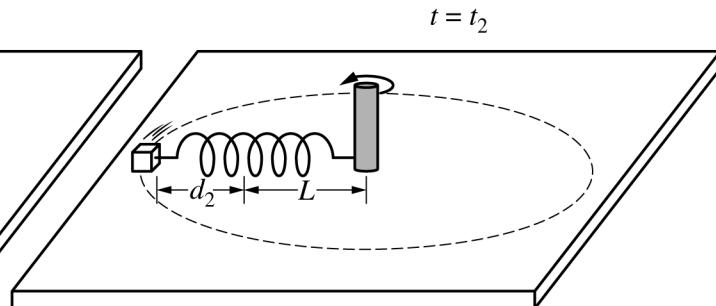


Figure 2

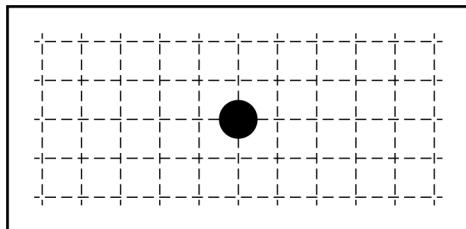
- (a) At time $t = t_1$, the rod is spinning such that the block moves in a circular path with a constant tangential speed v_1 and the spring is stretched a distance d_1 from the spring's unstretched length, as shown in Figure 1. At time $t = t_2$, the rod is spinning such that the block moves in a circular path with a constant tangential speed v_2 and the spring is stretched a distance d_2 from the spring's unstretched length, where $d_2 > d_1$, as shown in Figure 2.

GO ON TO THE NEXT PAGE.

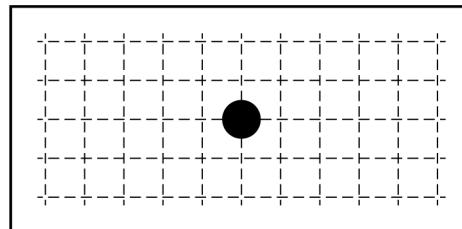
Continue your response to **QUESTION 3** on this page.

- i. On the following dots, which represent the block at the locations shown in Figure 1 and Figure 2, draw the force that is exerted on the block by the spring at times $t = t_1$ and $t = t_2$. The spring force must be represented by a distinct arrow starting on, and pointing away from, the dot.

Note: Draw the relative lengths of the vectors to reflect the relative magnitudes of the forces exerted by the spring at both times.



$$t = t_1$$



$$t = t_2$$

- ii. Referencing d_1 and d_2 , describe your reasoning for drawing the arrows the length that you did in part (a)(i).

- iii. Is the tangential speed v_1 of the block at time $t = t_1$ greater than, less than, or equal to the tangential speed v_2 of the block at time $t = t_2$?

$v_1 > v_2$ $v_1 < v_2$ $v_1 = v_2$

Justify your answer without using equations.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 3** on this page.

- (b) Consider a scenario where the block travels in a circular path where the spring is stretched a distance d from its unstretched length L .
- Determine an expression for the magnitude of the net force F_{net} exerted on the block. Express your answer in terms of m_0 , k_0 , L , d , and fundamental constants, as appropriate.
 - Derive an equation for the tangential speed v of the block. Express your answer in terms of m_0 , k_0 , L , d , and fundamental constants, as appropriate.
- (c) Does your equation for the tangential speed v of the block from part (b)(ii) agree with your reasoning from part (a) ?

Yes No

Explain your reasoning.

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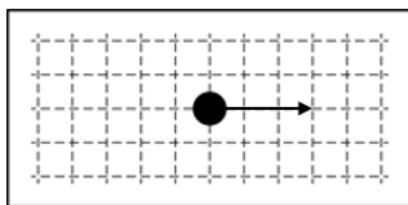
Question 3: Quantitative/Qualitative Translation**12 points**

-
- (a)(i) For drawing rightward arrows in both diagrams 1 point

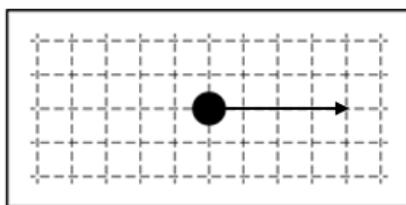
For the length of the arrow at $t = t_2$ being longer than the arrow at $t = t_1$ 1 point

Scoring Notes:

- A maximum of 1 point can be earned if extraneous unlabeled arrows are drawn.
- A maximum of 1 point can be earned if incorrect labeled forces are drawn.

Example Response

$t = t_1$



$t = t_2$

-
- (a)(ii) For an explanation that refers to the difference in the stretch length and indicates that the magnitude of the spring force is (or is not) related to the stretch length, consistent with the force diagram drawn in part (a)(i) 1 point

Example Response

The spring force arrow drawn at $t = t_2$ is longer because the spring is stretched a greater distance at that time and the spring force is related to the stretch distance.

-
- (c) For an answer that attempts to use functional dependence to relate the tangential speed with stretched distance **1 point**

Scoring Note: It is not necessary to use the functional dependence correctly to earn this point.

For a correct explanation for why the derived equation in part (b)(ii) does or does not support the reasoning in part (a) **1 point**

Example Response

My equation from part (b)(ii) agrees with my reasoning in part (a). The tangential speed of the block as it travels in a horizontal circle is related to the distance the spring is stretched. The greater the tangential speed of the block, the greater distance the spring is stretched. The equation shows this because the d is in the numerator.

Total for part (c) 2 points

Total for question 3 12 points