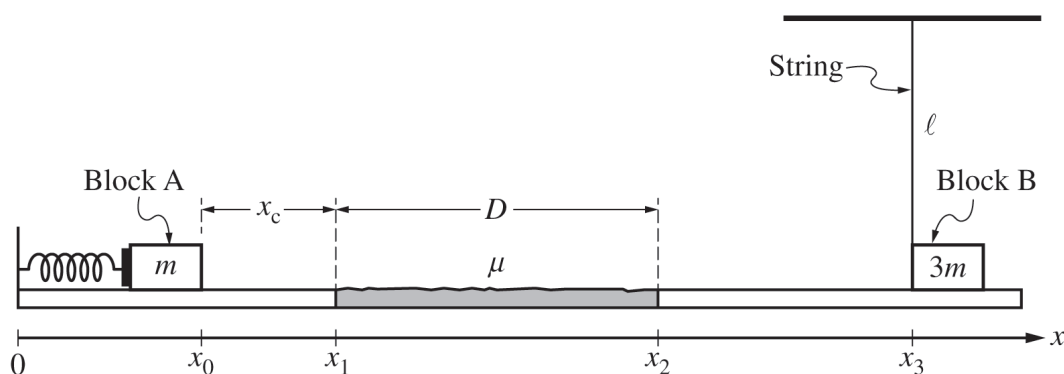


Begin your response to **QUESTION 1** on this page.**PHYSICS C: MECHANICS****SECTION II****Time—45 minutes****3 Questions**

**Directions:** Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



Note: Figure not drawn to scale.

Figure 1

1. Block A and Block B of masses  $m$  and  $3m$ , respectively, are arranged in a setup consisting of an ideal spring with spring constant  $k$  and a horizontal surface. Friction between the surface and the blocks is negligible except in a region of length  $D$ , where the coefficient of kinetic friction between Block A and the surface is  $\mu$ . Block B is attached to a string of length  $\ell$  and negligible mass, as shown in Figure 1. Block A is held against the spring, compressing the spring a distance  $x_c$ .

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Continue your response to **QUESTION 1** on this page.

At time  $t = 0$ , Block A is located at position  $x = x_0$  and is released from rest. After the block is released, the following occurs.

- At time  $t = t_1$ , Block A is at  $x = x_1$  after traveling a distance  $x_c$ . Block A moves with speed  $v$ , and the spring is at its equilibrium position.
- At time  $t = t_2$ , the left side of Block A is at  $x = x_2$  after passing through a distance  $D$  across the region with nonnegligible friction.
- At time  $t = t_3$ , Block A is at  $x = x_3$  and Block A collides with and sticks to Block B.

(a) For parts (a)(i) and (a)(ii), express your answer in terms of  $m$ ,  $k$ ,  $D$ ,  $\mu$ ,  $x_c$ , and physical constants, as appropriate.

i. **Derive** an expression for the speed  $v$  of Block A at time  $t_1$ .

ii. **Derive** an expression for the speed  $v_{A,B}$  of the two-block system immediately after the collision at time  $t_3$ .

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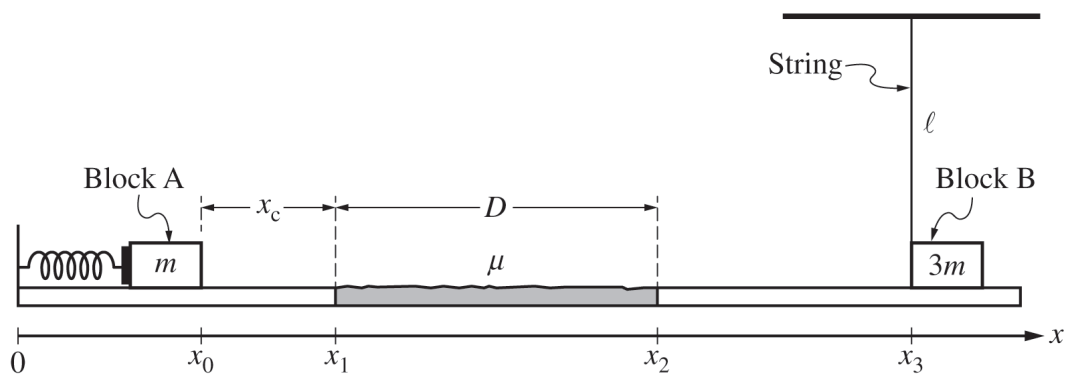
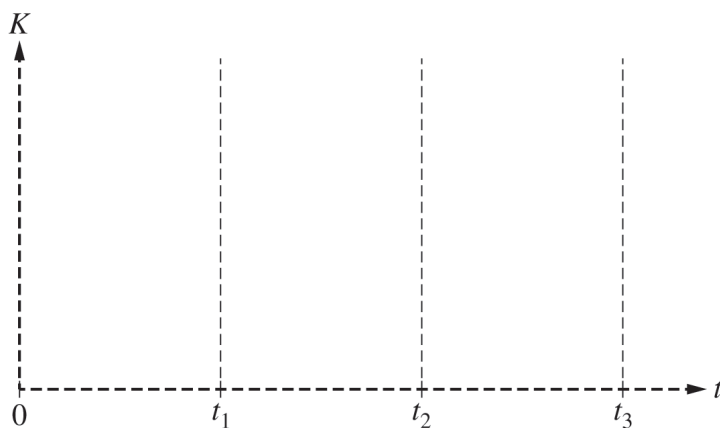
Continue your response to **QUESTION 1** on this page.Note: Figure not drawn to scale.

Figure 1

(b)

- i. On the following axes, **sketch** a graph of the kinetic energy  $K$  of Block A as a function of time  $t$  from time  $t = 0$  to time  $t_3$ .



- ii. Use principles of work and energy to **justify** the graph drawn in part (b)(i) for the time interval  $t = 0$  to  $t = t_1$ . Explicitly reference features of the shape of the graph you drew in part (b)(i).

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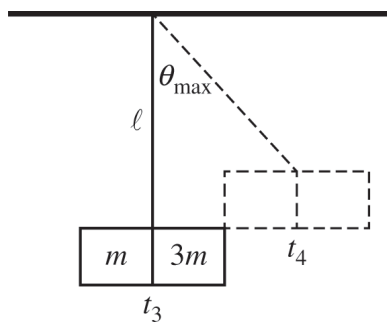
Continue your response to **QUESTION 1** on this page.Note: Figure not drawn to scale.

Figure 2

After the collision, the two-block system instantaneously comes to rest at time  $t_4$ , which occurs when the string makes a small angle  $\theta_{\max}$  with the vertical, as shown in Figure 2. For times  $t > t_4$ , the system oscillates with frequency  $f_\ell$ . The support holding the string is raised, and the procedure is then repeated using a new string of length  $2\ell$ .

(c) **Indicate** how the new frequency of oscillation  $f_{2\ell}$  of the system on the new string of length  $2\ell$  will compare to the frequency of oscillation  $f_\ell$  from the original procedure.

\_\_\_\_\_  $f_{2\ell} > f_\ell$       \_\_\_\_\_  $f_{2\ell} < f_\ell$       \_\_\_\_\_  $f_{2\ell} = f_\ell$

Briefly **justify** your answer.

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