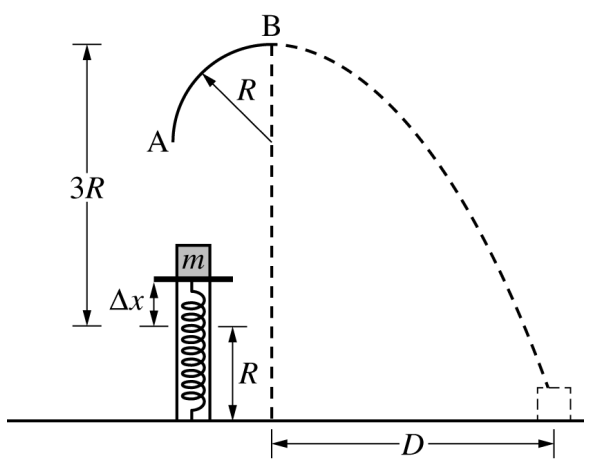
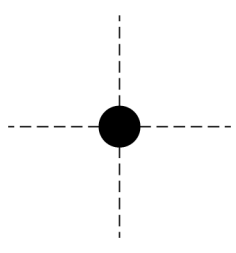
Begin your response to **QUESTION 3** on this page.




Note: Figure not drawn to scale.

3. A block of mass $m$ is placed on top of an ideal spring of spring constant $k$. The block is pushed against the spring, compressing the spring a distance $\Delta x$. The block is released from rest, leaves the spring at the position shown in the figure, travels upward, and enters a track with a constant radius of curvature $R$ that has negligible friction. The block enters the track at point A, maintains contact with the track, and exits horizontally at point B, a distance $3R$ above the point the block was released. The block then falls to the ground and lands a horizontal distance $D$ from the end of the track. Express all algebraic answers in terms of $m$, $k$, $\Delta x$, $R$, and physical constants, as appropriate. The size of the block is much smaller than the radius of curvature of the track.

(a) On the dot below, which represents the block, draw and label the forces (not components) that act on the block while still in contact with the track at point B. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.



Justify your choice of vectors.

**GO ON TO THE NEXT PAGE.**



(b)

i. Derive an expression for the speed $v$ of the block at point B.

ii. Derive an expression for the magnitude of the net force $F$ on the block at point B.

(c) Derive an expression for the minimum value of $\Delta x_{\text{min}}$ required in order for the block to maintain contact with the track through point B.

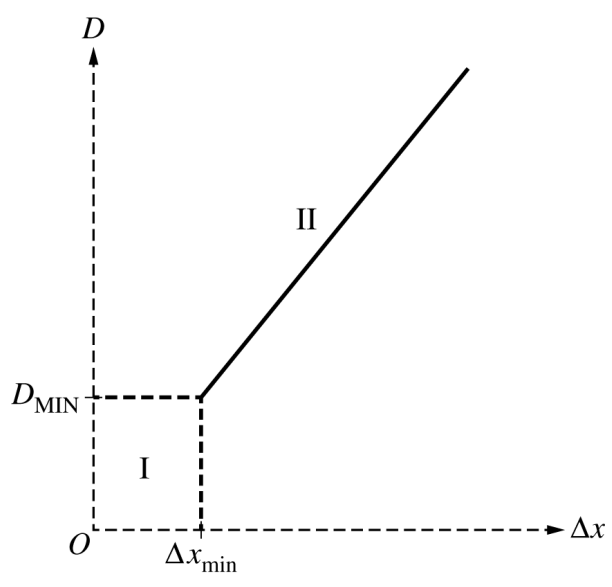
The procedure is repeated several times with the distance $\Delta x > \Delta x_{\text{min}}$.

(d) Calculate the distance $D$ that the block travels.

**GO ON TO THE NEXT PAGE.**



(e) The graph below shows the best-fit line drawn by the students through their data of $D$ as a function of $\Delta x$.




i. Explain why there are no data for section I of the graph.

ii. Explain the reason for the shape and minimum value of section II on the graph.

**GO ON TO THE NEXT PAGE.**



**STOP**

**END OF EXAM**