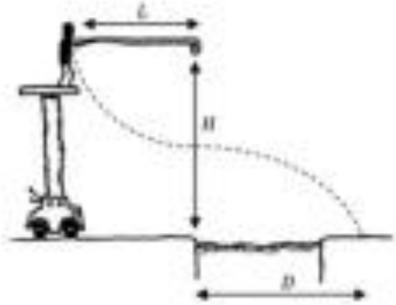
NAME ______________________ DATE ____________

Scenario

A designer is creating an obstacle for an obstacle course where a person starts on a moveable platform of height H from the ground. The person grabs a rope of length L and swings downward. At the instant the rope is vertical, the person lets go of the rope and attempts to reach the far side of a water-filled moat. The left side of the moat is directly below the position where the person will let go of the rope. The designer runs several tests in which the rope has different lengths and moves the platform such that the rope is always initially horizontal. The designer notices that the person cannot land on the other side if the length L is very short. The designer also notices that the person also cannot land on the other side if the length L is very close to the height H.



Assume the size of the person is much smaller than the lengths L and H. Let D represent the horizontal distance from below the release point to where the person lands.

Data Analysis

PART A: Answer the following qualitatively, citing physical principles but without manipulating equations.

i. Why does the person land in the moat if the rope's length is very short?

If the rope is short, then the gravitational potential energy of the person-Earth system that is converted to the person's kinetic energy is very small. This results in a small horizontal velocity when they let go of the rope. Even though the person will spend a longer time in the air after releasing the rope because they are free falling from a large height, the horizontal velocity is so small that they cannot travel far enough, so they land in the water.

ii. Why does the person land in the moat if the rope's length is nearly the same as the height of the platform?

If the rope is very long, the person-Earth system will have a lot of gravitational potential energy to convert into kinetic energy, so the person will have a large horizontal velocity when they let go of the rope. By the time that the person lets go of the rope, they are practically on the ground, so using free fall kinematic equations, the time for the person to hit the ground is extremely small. Even with a large horizontal velocity, the time to fall is too small for the person to travel a large enough distance, so they land in the water.

Quantitative Analysis

PART B: Using the variables given above and fundamental constants, write mathematical expressions for the following:

i. v, the horizontal speed of the person at the moment they let go of the rope

$mgL = \frac{1}{2}mv^2$ therefore $v = \sqrt{2gL}$

ii. The distance D

$y = H - L = \frac{1}{2}gt^2$, the fall time is $t = \sqrt{\frac{2(H-L)}{g}}$

The horizontal distance is then $D = vt = \sqrt{2gL}\sqrt{\frac{2(H-L)}{g}} = 2\sqrt{L(H-L)}$.

Argumentation

PART C: i. Describe how your equations from Part B (i) and (ii) support your reasoning in Part A (i).

If L approaches zero, D also approaches zero, since the first term $\sqrt{2gL}$ will also approach zero, meaning that the distance D traveled by the person is very small.

ii. Describe how your equations from Part B (i) and (ii) support your reasoning in Part A (ii).

If L approaches the same value as H, then the subtraction term in Part B (ii) goes to zero, meaning that the distance the person travels is very small.