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SIMIODE Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations

STUDENT VERSION
HANG TIME

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STATEMENT

Let us consider the phenomena known as "hang time" in sports. Often the announcer in a televised football game will refer to the hang time for a punter's kick or a basketball announcer will say a player appears to "hang in the air." What is that all about? Why would something appear to be so? We consider a one dimensional representation of an object going up and coming down and ask what the notion of hang time might suggest in this context.

Suppose we consider a basketball player about to take a jump shot.

a) Estimate how high his hip rises from his standing position to the top of his jump.

Suppose we try to model the height of his hip and let us say $y(t)$ is the height of his hip at time t seconds, where $y(0) = 0$ is the starting height shifted to compensate for his real hip height.

b) Newton's Second Law of Motion says that the sum of the forces acting on a body are equal to the product of the body's mass and it acceleration, $m * y''(t)$) it experiences can be computed by summing all the external forces acting on the body. Use that Law and the fact that the only force acting on the player's hip is due to gravity to build a differential equation for $y(t)$. What would be the initial conditions?

c) Solve the differential equation with one of your initial conditions being unknown. Which condition is unknown?

d) Based on your observations for (a) and your solution in (c) determine numerical values for your unknown initial condition.

e) Now use your model with your initial condition to determine the times at which the player's hip is at 75% of its maximal height.

f) Determine the entire length time of this player's jump.

g) What percentage of time does the player's hip spend higher than 75% of its maximum height?

h) Relate the finding in (g) to the appearance of hang time alluded to in the opening of this activity.