*Name*____________________

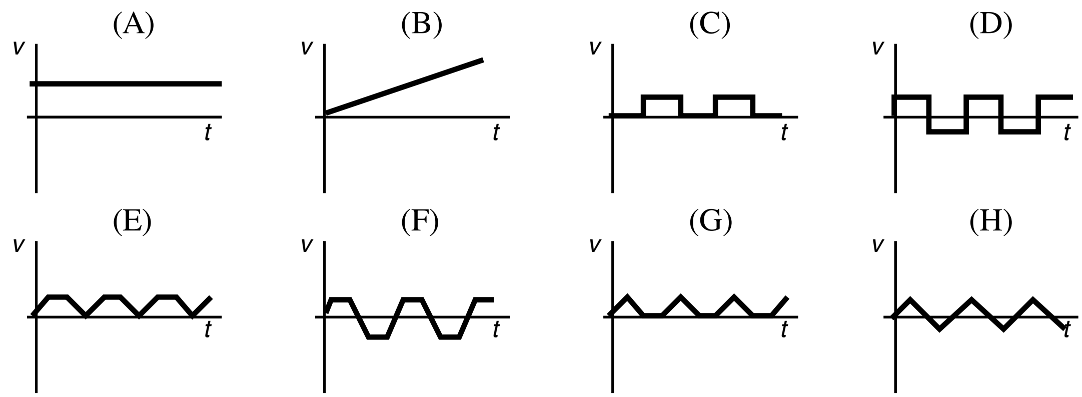
The Mechanics of Walking

A. **Record your group's results on a separate sheet of paper, selecting one person's set of measurements. Also practice walking like each graph.**

1. Make one-second strides (count off seconds as "one-Mississippi, two-Mississippi, *etc.*," and walk in such a way that the your right foot always repeats itself every second.

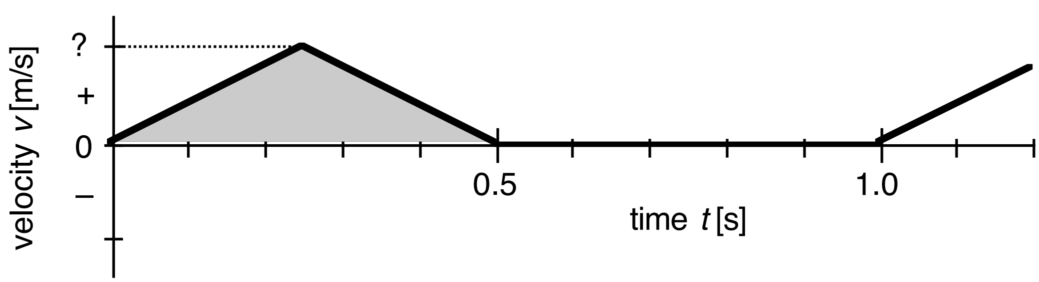
(a) Measure the length of your right-foot-to-right-foot stride, in cm. (1" = 2.54 cm.)

(b) ***Act out each of the horizontal velocity v(t) graphs below, and discuss which must be eliminated as being impossible depictions of the motion of your right heel while walking.***



B. **Analysis of walking motion.**

2. Model the motion of your right heel with graph (G), where the stride time interval is one second[1]. Knowing that *the area contained under the v(t) graph for one stride is the distance covered by your foot in one stride,* determine the maximum horizontal velocity (in cm/s) of your right foot. (FYI: 1 cm/s = 2.23694×10^{-2} mph.)



*Name*____________________

More Kinematics and Graphical Analysis

A. Making $v(t)$ graphs. Discuss the given information below in your group, and record your velocity versus time graph for the basketball up on a separate sheet of graph paper. You will later scale this graph in the second half of this activity.

1. Consider the horizontal motion of a basketball as described below. Sketch one $v(t)$ graph that consecutively shows all three motions, and explain physically which direction you have (arbitrarily) chosen to be the positive velocity direction. Assume that the velocity graph consists of three line segments. (Also assume that the basketball has long since left the hand of the person throwing it, and neglect any effect of air resistance or friction throughout its motion.)

- From $t = 0$ seconds to $t = 0.80$ seconds, it rolls at a constant speed of 1.2 m/s towards a wall.
- From $t = 0.80$ seconds to 0.82 seconds, it is momentarily in contact with ("bouncing off of") the wall.
- From $t = 0.82$ seconds to 2.42 seconds, it rolls back at a constant speed to where it started from.

B. Quantitative analysis of the $v(t)$ graphs.

2. Scale the vertical ± velocity values for your $v(t)$ graph. In your analysis, you should determine somehow the distance between the initial position of the basketball at $t = 0$ seconds, and the wall. Show your work and explain your reasoning.

3. Calculate the average acceleration of the ball during the time interval from t = 0.80s to
t = 0.82s. Is it positive or negative? How is the acceleration related to your graph? Show your work and explain your reasoning.

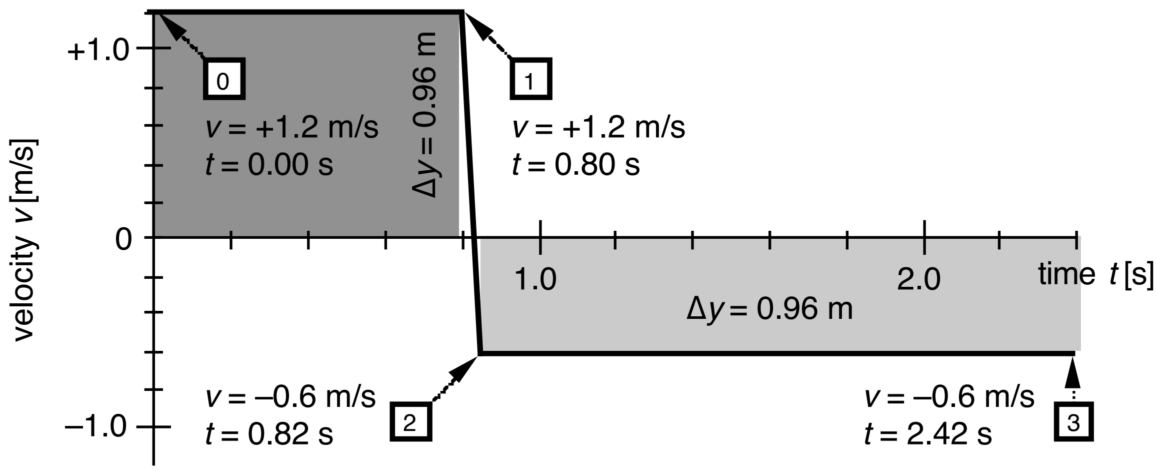
*Name*____________________

Activity Cycle 8.2.1: TA instructions

The distance from the initial position of the basketball to the wall is the area bounded by the velocity graph from [0]→[1]. Since the constant velocity ("height") and time elapsed ("base") are given, this distance is the rectangular area, which is 0.96 m.

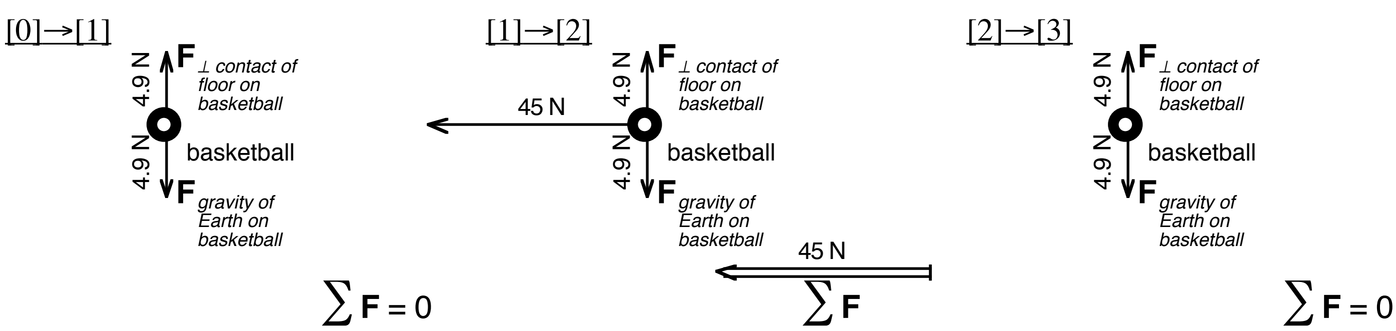
Note that we are ignoring the two triangular areas in [1]→[2]. Strictly speaking, these two areas must be equal (they are related to how much the ball "squishes" against the wall), and realistically cannot be connected with a straight line segment!

The basketball must make it back to its original position at 2.42 s; it has 1.60 s ("base") to travel 0.96 m ("area"). Thus the constant backwards velocity ("height") must be –0.60 m/s.



Making the force diagrams requires something new—instead of *integrating* the $v(t)$ graph, students need to *differentiate*, finding the slopes (accelerations) from [0]→[1] ($a = 0$ m/s^2), from [1]→[2] ($a = -90$ m/s^2), and from [2]→[3] ($a = 0$ m/s^2). From Newton's Second Law, the magnitudes of the net force are respectively 0 N, –45 N, and 0 N.

Many students will include the force of the hand on the basketball—watch out for strange "impetus" forces, and for the direction of the ⊥ contact force (which way did students define the positive horizontal direction?).



*Name*____________________

Activity Cycle 8.2.1: Method of Oresme: freefall with no drag

Learning goals:

- Apply the method of Oresme describe the motion of and quantify the forces acting upon an object.

A. **This is an open-ended activity in the sense that you are given several objectives, but are not given an explicit procedure. You may need to work this problem using several different approaches, and in the end make everything consistent with each other.**

Consider the *vertical* motion of an $m = 0.5$ kg basketball as described below.

[0] At $t = 0$ seconds, it is moving straight *upwards* with a speed of 2.0 m/s. (Assume that it has long since left the hand of the person throwing it, and neglect any effect of air resistance throughout its motion.)

[1] At some unknown time, it reaches it maximum height.

[2] At some unknown time, it is moving *downwards* with a speed of 2.0 m/s, past the point at which it started its motion at $t = 0$ seconds.

1. Draw a $v(t)$ graph for the basketball, and scale the vertical v and horizontal t axes. What time did the basketball reach its highest height? *Hint: what must the slope of your $v(t)$ graph be?*

2. Determine the maximum height of the basketball, above the point at which it started its motion at $t = 0$ seconds. *(Although it is possible to do so, do not use the initial-final energy conservation approach developed in Physics 7A to answer this question. Concentrate on using the method of Oresme instead!)*

3. Make three separate force diagrams, as seen from the side, for the basketball for the three instances in time described above. Properly label each force vector. Use a scale of
1 cm ↔ 1 N, but also write down the magnitude of each force, in N. $g = 9.8$ N/kg. Indicate the $\sum \vec{\mathbf{F}}$ net force vector (*magnitude and direction*) separately on the side, for each case.

B. **Ensuring that everything is self-consistent. Revise your work above as necessary, when going through the consistency checks below.**

4. What is the slope of your $v(t)$ graph at each of the instances in time described above? Show that these $v(t)$ slopes are consistent with the magnitude *and* direction of your $\sum \vec{\mathbf{F}}$ net force vectors. *Is the ± sign of your slope consistent with the direction of your net force vector?*

5. What is the total area bounded by your $v(t)$ graph from $t = 0$ seconds to when the basketball reaches it maximum height? What is the total area bounded by your $v(t)$ graph from $t = 0$ seconds to when the basketball falls downwards past its starting point?

*Name*____________________

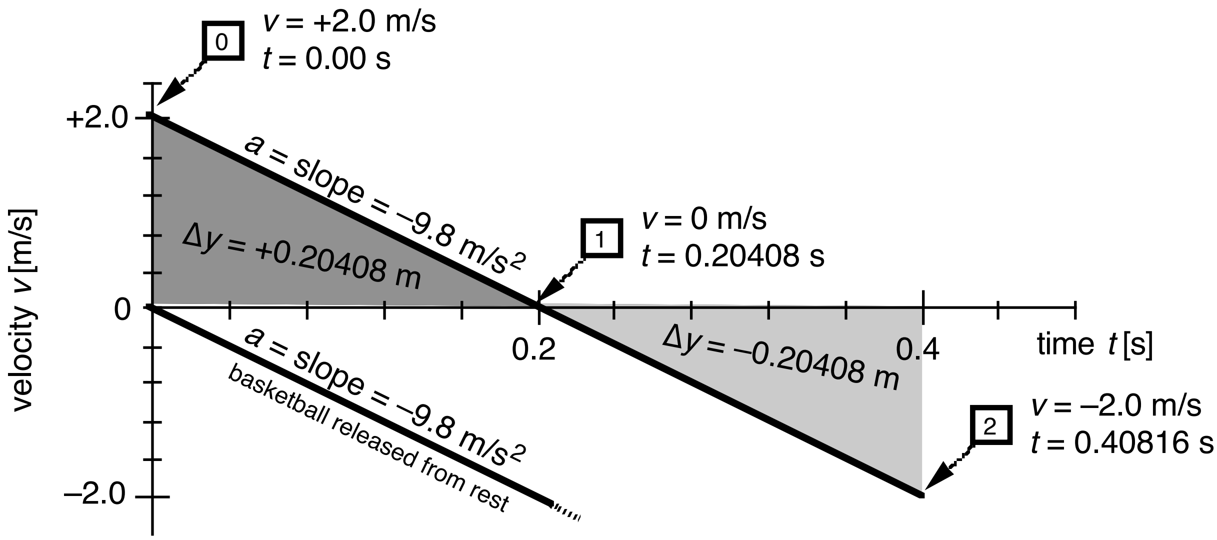
6. On the same $v(t)$ graph that you have drawn on the board, show the motion of a basketball that just after released from rest, and allowed to fall downwards towards the floor.

*Name*____________________

Activity Cycle 8.2.1: TA instructions

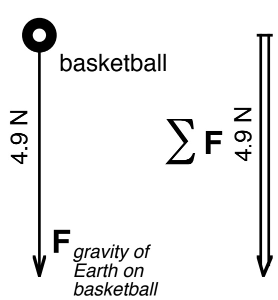
The slope of the $v(t)$ graph is –9.8 m/s^2, that is, if the students choose up as the positive direction. Knowing that the rise of the slope must be Δv = –2.0 m/s (the basketball has a velocity of +2.0 m/s at [0], and slows down to v = 0 m/s at [1]), the run must be Δt = 0.20408 s.

The triangular area bounded by the $v(t)$ graph is +0.20408 m from [0]→[1], which is the maximum height of the basketball. The triangular area bounded by the $v(t)$ graph from [1]→[2] is –0.20408 m, such that the total area from [0]→[2] is 0 m, as it returns back to the same place. (The factor of ten or 0.1 that seems to propagate throughout is because g = 9.8 m/s$^2 \approx$ 10 m/s^2.)

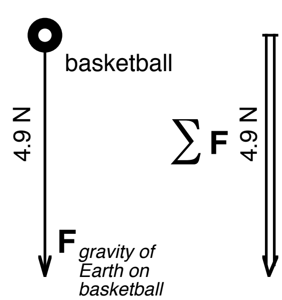


Drawing the force diagrams is where many students have conceptual difficulties—should $\sum \vec{\mathbf{F}} = 0$ at [1]? After all, isn't velocity zero there? What about the ⊥ contact force of the hand that originally put the basketball into motion? Note that the force diagrams are identical *throughout* this process.

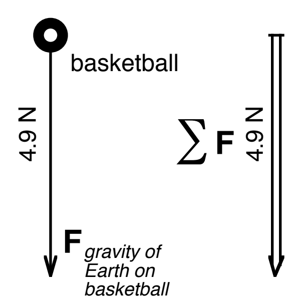
[0]→[1]



[1]→[2]



[2]→[3]



*Name*____________________

DLM 08 Exit handout

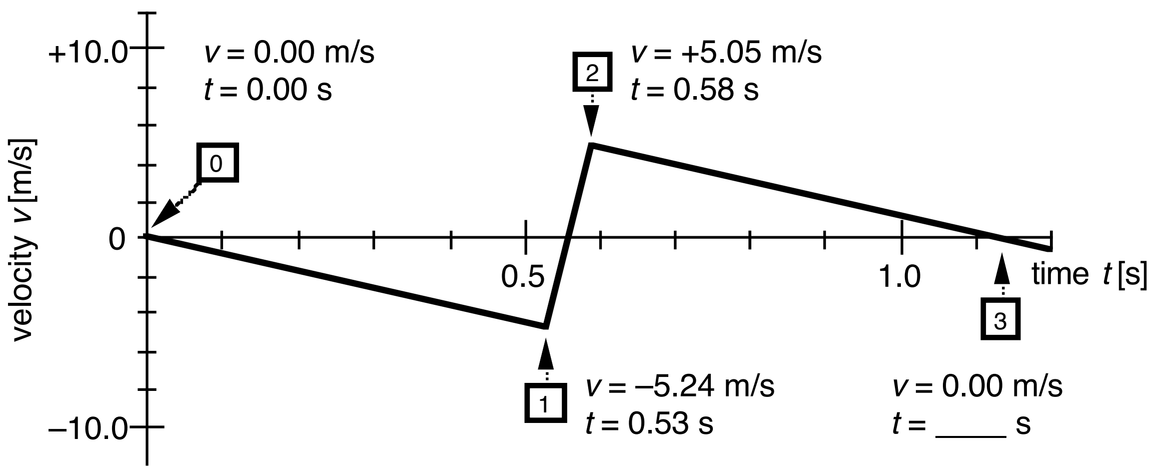
Announcements

Quiz 7 will be given during lecture on Tuesday, October 29, and will cover the material in Block 7. Bring a pen or pencil, calculator, and prepare to show your UC-Davis student ID card (or similar photo ID) upon entering, and/or during the quiz.

FNT ("For Next Time")

Consider the *vertical* motion of an $m = 0.5$ kg basketball as described by the graph below.

- At $t = 0$ seconds, its center of mass originally starts at some unknown height above the floor.
- It falls straight downwards, bounces off of the floor, and then moves upwards to an unknown shorter maximum height. *Throughout this problem, neglect the effect of air resistance on the basketball!*



1. Determine the maximum height of the (center of mass of the) basketball above the floor at $t = 0$ seconds (time [0]), and the maximum height above the floor at time [3]. *(Although it is possible to do so, do not use the initial-final energy conservation approach developed in Physics 7A to answer this question. Concentrate on using the method of Oresme instead!)*

2. Determine the time (in seconds) for [3].

3. Make three separate force diagrams, as seen from the side, for the basketball for the three time intervals [0]→[1]. [1]→[2], and [2]→[3]. Properly label each force vector, but also write down the magnitude of each force, in N. Use $g = 9.8$ N/kg. Indicate the $\sum \vec{\mathbf{F}}$ net force vector (*magnitude and direction*) separately on the side, for each case.

*Name*____________________

4. Take a ride—in the Physics/Geology building elevators! Sit in the silver chair (don't fret—it will push down as you sit on it), which records your weight (in lbs). This may require two people; one to sit in the chair, the other to read off your weight as measured by the chair.

- Record values of your weight (in lbs) while going up—first at rest; speeding up; upwards at constant speed; slowing down; at rest at top floor, for a total of five measurements. Convert to this weight to the gravitational force of the Earth on you, in N (2.2 lbs = 9.8 N).
- Now do this again, estimating how much time (to the nearest half-second) it takes for the elevator to speed up, to move at constant speed, and then to slow down, for a total of three time intervals. Use a watch, or count off seconds.

Draw properly labeled and scaled force diagrams for you (the elevator passenger) for the five different situations for going up. (Note that the $\mathbf{F}_{\perp\ \textit{contact of you on cha}}$ (what the chair scale "reads") is the Third Law pair of $\mathbf{F}_{\perp\ \textit{contact of chair on yo}}$.) Draw the net force $\sum \vec{\mathbf{F}}$ vector next to each of your five force diagrams, and indicate its magnitude (in N) and direction for each case.

5. Read the Block 8 Glossary in the *Physics 7B Student Packet, Fall 2002*, and familiarize yourself with the following term that will be introduced in DLM 09.

force, drag