Physics 7B

DLM 8 Overview

Unit 4: Angular Momentum and Torque

Model/Approach: Angular Momentum Conservation Model

Act-4.3.7 Finish this activity, if needed **(~40 min)**

Unit 5: Newtonian Model

Act-5.1.1 Newton's 2nd Law Model vs Conservation Models. FNTs of DLM 8 **(~60 min)**

Learning Goals:

- Clarify any remaining questions about how to analyze physical phenomena using conservation of momentum and angular momentum: FNT 1 from DLM 7
- Develop understanding of the differences between a Newtonian 2nd law approach and a momentum conservation approach and how these relate to energy conservation
- Get practice figuring out which model/approach can be used to answer particular questions about various phenomena.
- Review Newton's 1st and 3rd laws
- Develop understanding of the steps used in the Newtonian 2nd law approach

Act-5.1.2 Using the Newtonian Model to Analyze the Motion of dropped Objects **(~40 min)**

Learning Goals:

- Get practice using Newton's 2nd law approach to make sense of the behavior of the real behavior of dropped objects
- Practice extracting meaning from velocity and acceleration graphs

Announcements

- **Reading Assignment** - Read Summary and Review pages 107-120 and read Unit 6 through page 66.

A. DLM 07 FNT 1: Wrap-up of Momentum Conservation Models

In Your Small Group

1) Put on the board any questions your group still has concerning any of the activities from DLM-7.

2) Put on the board your analysis of the phenomena from DLM 7 involving the bike wheel or rotating stool as directed by your DL instructor.

Whole Class Discussion

B. FNTs of DLM 7: Newton's 2nd Law vs. Conservation Models

1) Newton's Laws

In Your Small Group discuss the following and put your responses on the board

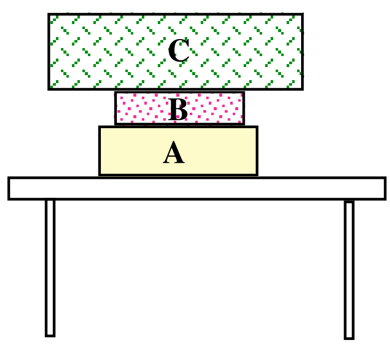
1) **FNT 2**: Share your examples of Newton's three laws. Choose one example of each law to put on the board. Describe each law in both sentence form and with a concise mathematical expression. Be careful and precise with notation in the algebraic expressions.

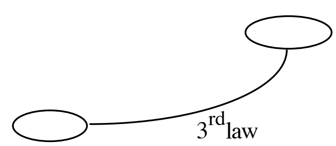
2) Compare your individually created momentum charts and force diagrams for FNT 3 & 4. Explain how Newton's Laws can be identified in both the momentum charts and diagrams.

   In order for the rocket to move at a constant speed does it need to have a net force on it?

Whole class discussion

3) Compare your individually created force diagrams for FNTs 4, 5, and 6. On the board, make a force diagram of **each** object, the three books and the table (the masses of the books are 0.8 kg, 0.2 kg, and 0.5 kg for books A, B, and C, respectively and the mass of the table is 30 kg). Be sure to circle all third law pairs!





   Make certain each member of the group is able to defend the value of each force using the Newtonian model.

4) If the books and table are sliding across the room each at the same constant speed, how would your force diagrams change? Show precisely how it would change or explain why it would not.

5) Now imagine the table is sitting in the elevator that begins to accelerate upward with an acceleration equal to 2 m/s^2.

   a. Make a new force diagram for each book and determine the forces acting on it.
   b. Create a momentum chart for this situation.
   c. Does each object experience a net force? If so, of what magnitude and direction?
   c. Is it correct to say a force always equals ma?

Using Newton's 2nd Law Model to Analyze the Motion of Dropped Objects

A) Motion of Dropped Objects

Phenomenon: Dropping a wadded up piece of paper and a flat bottomed coffee filter

1. **Observing the Motion. Do (a) and (b) as a group, then put up (c) on the board.**
   a) Obtain a flat-bottomed coffee filter that still has it original shape. Wad up a piece of paper until it is in the shape and size of a golf ball. Drop both simultaneously from a height of about six feet.

   b) Carefully observe the motion of the two objects.

   c) Write out a description of the motion you observed using the terminology "velocity."

   a) Sketch a velocity graph (the vertical component) for each object on the same set of velocity versus time axes.

2. **Analyzing the Motion. Discuss (a), (b), and (c) as a group while you work on the board.**

   a) Create force diagrams for both objects at two times, first at the instant each object has been released and second after each has fallen about 1/4 of the way to the floor. Show the net force vector explicitly. What does this tell you about the accelerations of these two objects as they fall? Apply Newton's 2nd law to both objects in order to determine their accelerations. **Put all of this on the board.**

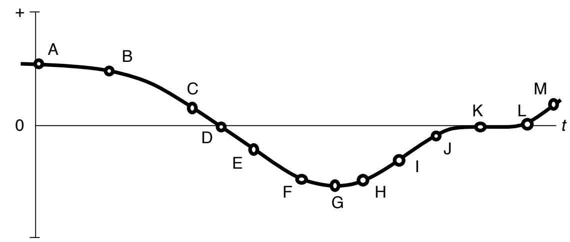
   b) Use the accelerations you obtained in (a) along with the actual motions you observed to make an acceleration graph for these two dropped objects from the time they are released to just before hitting the floor. **Put these graphs on the board.**

   c) What is the mathematical relation between the instantaneous acceleration and the instantaneous velocity? How does this relation show up on the two graphs you made for the two cases? Adjust your curves to be consistent with both (b) and (c)

Be prepared to share your responses with the whole class.

1. Interpret the graph to the right as representing the velocity of an object. Rank the points in order of increasing acceleration (from most negative to most positive).

Practice walking this plotted motion.



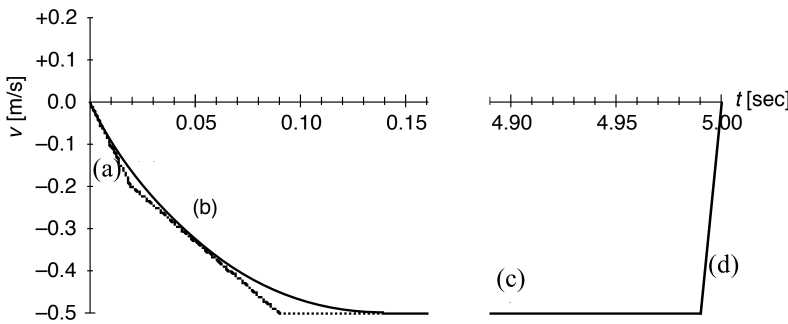
2 The velocity graph of a 1 g coffee filter released from rest is shown at right. Note the break in the time axis. Four distinct intervals are shown on the graph.

(a) Speed downward increasing from rest, 0 s ≤ t ≤ 0.02 s.

(b) Speed downward increasing, 0.02 s ≤ t ≤ 0.09 s.

(c) Speed downward is constant, 0.09 s ≤ t ≤ 4.99 s.

(d) Landing on the floor, 4.99 s ≤ t ≤ 5.00 s.



Draw an acceleration graph for the same time intervals above. You may use the tangent lines drawn on the velocity graph to calculate the average slopes of the velocity curve during the fist two intervals.

3.

Refer to the graphs on the reverse which were made using a motion detector mounted above a basketball that was dropped from a height of 1.5 m above the floor. The position measured and indicated is really the position of the top surface of the ball. The velocity graph was computed by the software as the derivative of the position vs. time graph. Complete the following tasks related to this situation.

a) Determine accurately the acceleration from the velocity graph and plot it on the acceleration axis. Make sure you extend the acceleration curve as far as the other two are extended in time.

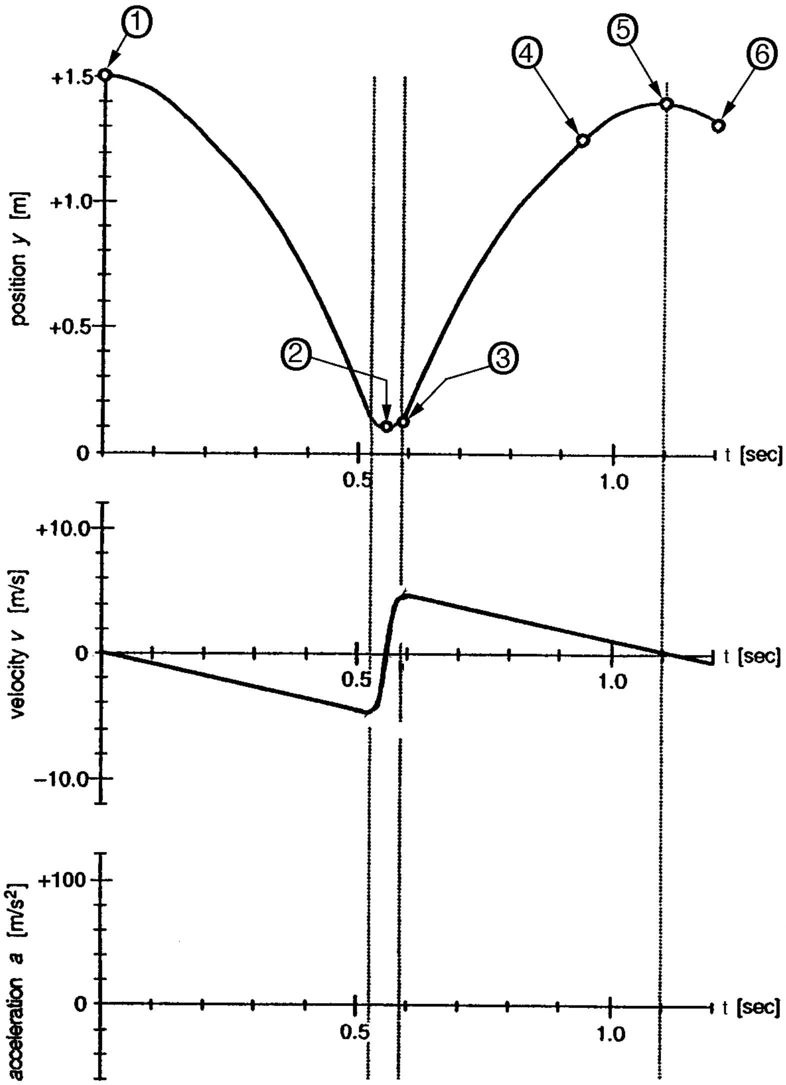
b) Describe the motion of the ball at the six indicated times numbered [1] to [6]. That is, describe where it is located and say something about its speed, direction of motion, and acceleration. If you look closely, you should see that at position [3] the ball is still in contact with the floor.

c) Draw force diagrams for each of the six marked times. For which times are the force diagrams identical?

d) For the times when the force diagrams are identical, which aspects of the motion are identical? Which aspects are different? Are your answers to the previous two questions consistent with Newton's 2nd law?

e) Determine the average value of the force exerted by the floor on the ball between the times numbered [2] and [3] two different ways. (1) from the impulse imparted to the ball from the floor and the velocity graph and (2) using Newton's 2^{nd} law. Explain two ways (once for each approach) why the force of the floor on the basketball when it bounces is so much greater than the basketball's weight.

Exit Handout



4. Consider the following "problem" that many beginning physics students struggle with: "How is it that at a certain instant in time, an object can have zero velocity, but at that same instant, have a non-zero acceleration?" Figure out how to explain this using the graphs of the motion of the dropped and bouncing basketball, the basic definitions of velocity and acceleration, **and** Newton's 2nd law.

5. Cart and Horse Paradox

The paradox is this: If a horse pulls on a cart, and the cart pulls back on the horse with an equal magnitude force, how can either possibly begin to move?

Use what you have learned about force to give a complete explanation of this paradox. (For a complete explanation, you might want to make complete force diagrams for 1) the horse, 2) the cart, and 3) the whole system (horse+cart).)