Concepts of Physics: Homework 3

Due: 13 September 2024

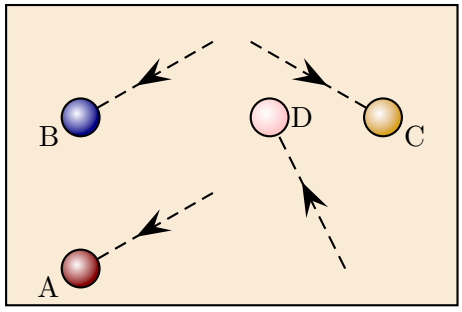
1 Mouse versus elephant

A mouse and an elephant each run in a straight line. The mouse runs at speed 3.0 m/s and the elephant at speed 9.0 m/s. Each starts at rest and the mouse runs for 15 s and the elephant for 3.0s. Which of the following is true? Ignore the brief moment when they accelerate. Explain you choice.

i) The elephant travels further than the mouse.
ii) The mouse travels further than the elephant.
iii) They travel the same distance.

2 Pool balls

Several pools balls collide. At some stage after the collision the balls move on the pool table along the illustrated paths. Ball A moves with speed 12.0 m/s, ball B moves with speed 12.0 m/s, ball C moves with speed 12.0 m/s, and ball D moves with speed 15.0 m/s.

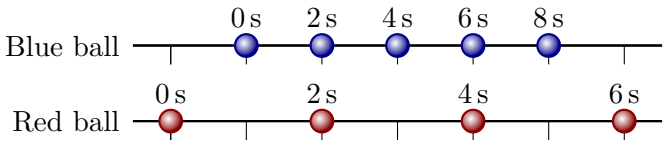


a) List all pairs of balls that have the same velocity as each other. Explain your answer.

b) List all pairs of balls that have the different velocities to each other. Explain your answer.

3 Racing balls

Two balls race each other. The locations of each ball are photographed at instants 2 s apart. The following questions apply to the period from 0 s to 6 s.



a) Which ball has the larger speed? Explain your answer.
b) Which ball has the larger acceleration? Explain your answer.
c) Suppose that the marks are 30 cm apart. Determine the speed of each ball.

4 Accelerating car

A car travels in a straight line to the right. At one moment it moves with speed 4.5 m/s (roughly 10 mph). At another moment 10 s later it it moves with speed 15.5 m/s (roughly 35 mph). Determine its acceleration during this period.

5 Aircraft takeoff acceleration

If you have flown in an aircraft, you will probably have noticed your acceleration during takeoff (you can feel the back of the seat pressing). Estimate the acceleration of a commercial jet aircraft using the takeoff speed and time to take off and compare your estimate to the acceleration you feel when falling vertically (9.8 m/s^2). To do this you will have to:

i) Look up the takeoff speed of a commercial aircraft (e.g. Boeing 737, Airbus A320) and convert this into m/s (Google can do that for you).

ii) Estimate the time taken to take off.

iii) Use the takeoff speed an time to find acceleration.

Note that this will give an estimate - that's all one wants. The actual details of takeoff will depend on weather, altitude, how full the aircraft is, etc.

6 Predicting velocity using acceleration

A blue ball and a red ball both travel to the right. At an initial instant the red ball has speed 20 m/s and the blue ball has speed 12 m/s. The acceleration of the red ball is 2.0 m/s^2 and that of the blue ball is 4.0 m/s^2.

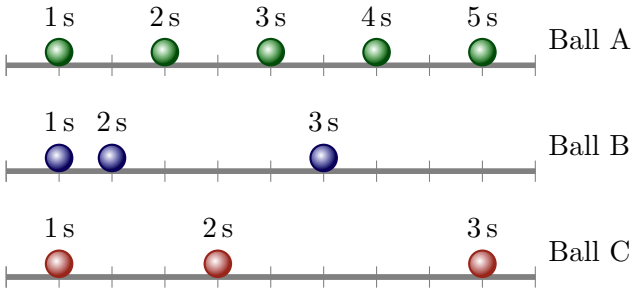
a) Determine the velocity of each ball 2.0 s after the initial instant.

b) Determine the velocity of each ball 3.0 s after the initial instant.

c) Both balls are observed at the same instant later. Will the red ball definitely be moving faster than the blue ball at this later instant? Explain your answer.

7 Speed and acceleration

Three balls move as illustrated. The positions of the balls are recorded at intervals spaced 1 s apart.



a) Which of the balls travel with constant speed and which travel with changing speed? Explain your answer.

b) Consider the average speed of each ball in the interval from 2 s to 3 s. Rank the balls in order of average speed (from smallest to largest) during this interval. Explain your answer.

c) Which of the balls travel with acceleration exactly equal to zero? Explain your answer.

d) Use the motions of these balls to decide whether the following statement is true: "If one object travels with a greater acceleration than a second object, then the speed of the first object is always larger than the speed of the second object." Is this statement correct or not? Explain it based on the motions of the illustrated balls and your answers the the previous parts of this question.

8 Bicycle vs. aircraft

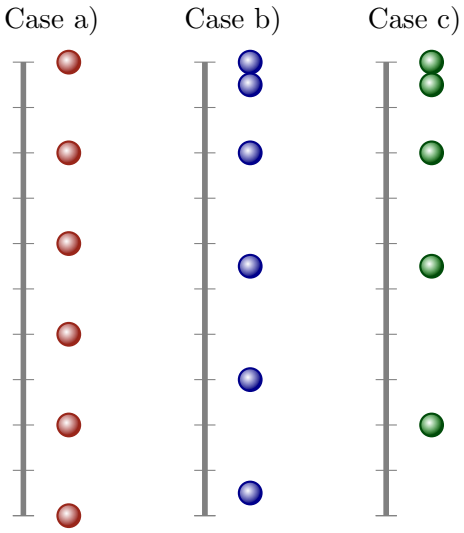
Suppose that an aircraft passing overhead maintains a constant speed of 400 mph. During the time that it passes above you, you pedal your bicycle from rest to a speed of 10 mph. Do you or the aircraft have a greater acceleration? Explain your answer.

9 Bouncing ball

A ball is thrown against a wall with a speed of 20 m/s and bounces back with a speed of 20 m/s. Is the acceleration of the ball zero or non-zero from the moment just before it hits the wall until the moment just after it hits the wall? Explain your answer.

10 Freely falling balls

A ball is allowed to fall and photographs of its position are taken every 0.10 s. Which of the following represents the correct sequence of positions? Ignore air resistance and explain your choice.



11 Moving man activity

Go to the moving man animation at:

http://phet.colorado.edu/en/simulation/moving-man

Run the moving man animation. Click on the Introduction tab. Set the position to -10 m, the velocity to 2 m/s, and the acceleration to 1.0 m/s^2 (type the numbers into the box; to reset hit the "Reset All" button). Run the animation and hit stop when the man hits the wall. You can replay the motion by hitting using "Playback."

a) Does the man appear to speed up as time passes?

b) Predict the velocity of the man at 1.0 s, 2.0 s, 3.0 s, and 4.0 s.

c) Use the animation to check the velocities of the man at those times. Do they match your prediction.

d) Use the animation to determine how far the man moves from 0 s to 1 s.

e) Consider the distances traveled by the man in the interval 0 s $\rightarrow$ 1 s and in the interval 1 s $\rightarrow$ 2 s. Do you expect that the distance in the later interval is the same as, larger, or smaller than the distance in teh earlier interval. Explain your answer.

f) Use the animation to determine how far the man moves from 1 s to 2 s. How does this compare (same, larger, smaller) to the first 1 s interval? Does this agree with what you expected?