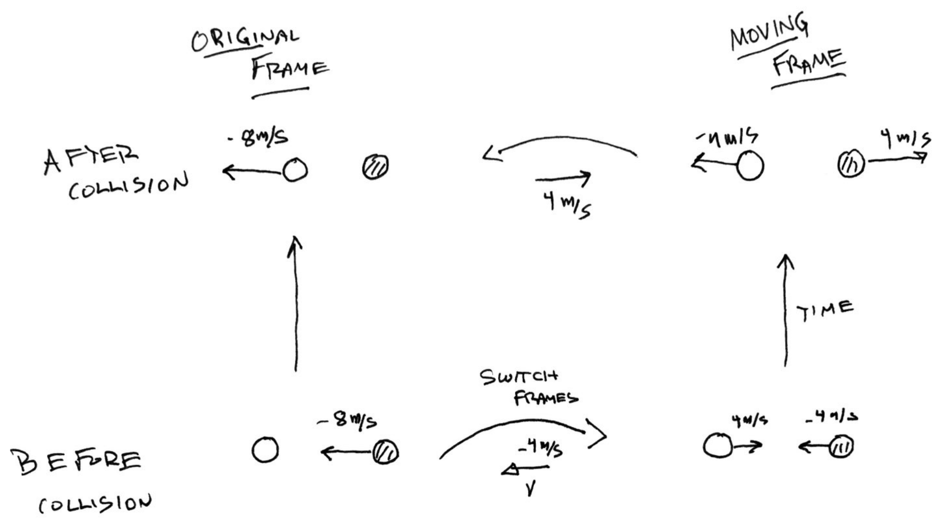
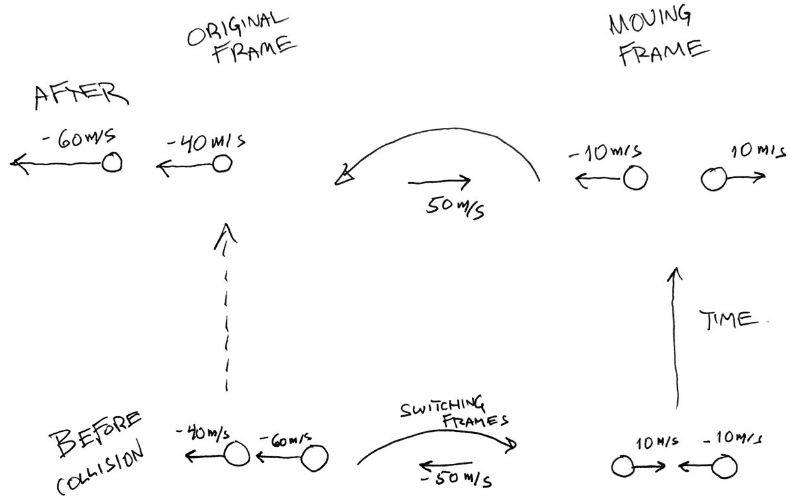
1. Solutions:

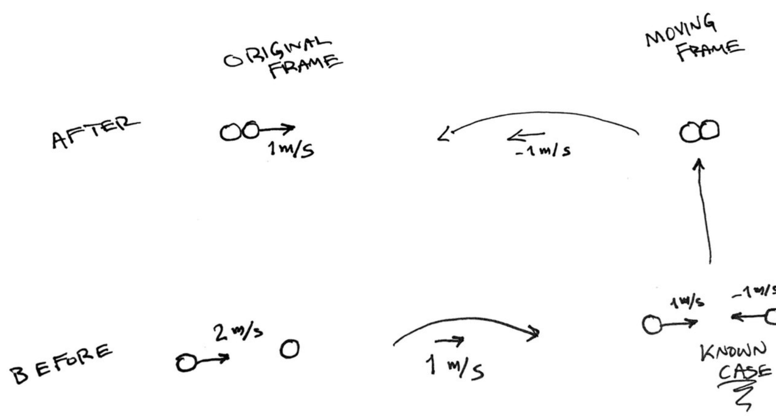
(1) In the collision of two identical elastic balls collide we have seen that when they approach at the same speed then after the collision they recede at the same speed.
   (a) We need the frame in which the objects approach at the same speed. This is the frame that moves left at -4 m/s. This is done graphically on the first line of the sketch.
   (b) In the new frame the balls collide and recede at 4 m/s. Switching frames back by moving right at 4 m/s gives the result in the original frame. The ball on the left moves at -8 m/s. This is done in the diagram below.
   (c) The relativity principle. This is what "switching frames" method is based on.



(2) I'll use the same "switching frames" method as in the first problem.
   (a) Shown in the lower left of the sketch.
   (b) To switch frames to a known situation we need to choose a frame moving left at 50 m/s. (The velocity is -50 m/s.)
   (c) The new frame has the balls approaching at 10 m/s. They collide and bounce away at the same speed - all in the new frame. Switching back to the original frame by moving right at 50 m/s produces the configuration shown on the upper left in the sketch; The ball on the left moves at -60 m/s and the one on the right moves at -40 m/s.



(3) Two identical, sticky objects: The transform the collision to a known case, we should switch to a frame moving right at 1 m/s. In this frame the objects move toward each other at the same speed. Being sticky they come to rest like the velcro-equipped gliders on the air track. Switching back to the original frame by moving left at 1 m/s means that in that original frame the stuck objects move at 1 ms. Here's the sketch:



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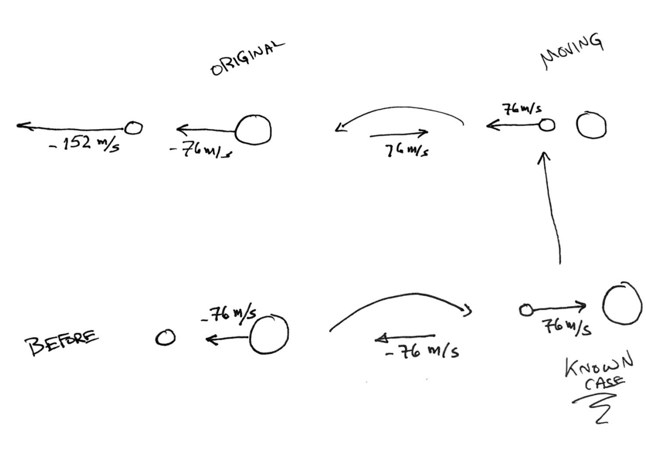
(4) The known case for a "small" ball - "big" ball collision is the frame in which the big ball is at rest. So we first move the rest frame of the big ball, moving at -76 ms^{-1}. Now in this frame the small ball moves at 76 ms^{-1}. After the collision it reverses its direction and moves away at -76 ms^{-1}. Switching frames back to the original frame by moving at 76 ms^{-1} gives the result - the small ball moves at 152 ms^{-1} (!). Here's the sketch:



(5) (a) Assuming the distance d is known. Record the time T when you hear the beep. Then the time when the beep sounded is

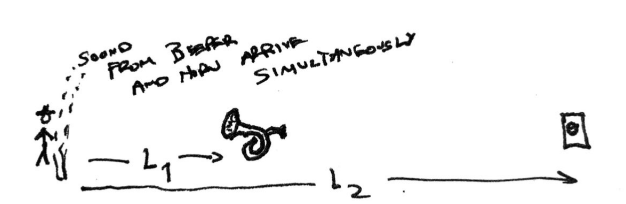
$$T - \frac{d}{c_s}$$

where c_s is the speed of sound.

(b) Many possible solutions here but one is to position an assistant with a clock near the beeper to record the time when the beeper sounds.

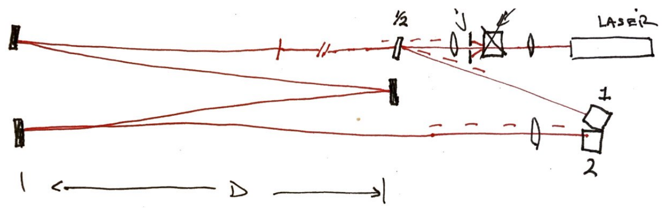
(6) No. All the phenomena does not depend on inertial frame - with one minor exception all these situations are approximately inertial reference frames. You could argue that taxiing may be non-inertial since it can involve turns, which require acceleration. Turbulence while flying also causes acceleration and thus makes the airplane's frame non-inertial.

(7) Here's a sketch of the situation described



including the sound wave fronts arriving at the observer at the same time. Because the beeper on the right is further away than the horn, it must have gone off earlier. The beeper sounds then the horn. You can also see this ordering of events by noting that the horn player could wait for the signal from the beeper before playing.

(8) In class we took measurements to determine the speed of light. On the scopes we found a time delay of about 62 ns while we measured the distance of one arm of the "folded path" of the reflected pulse to be about $D = 446$ cm. Here's a diagram of the experiment

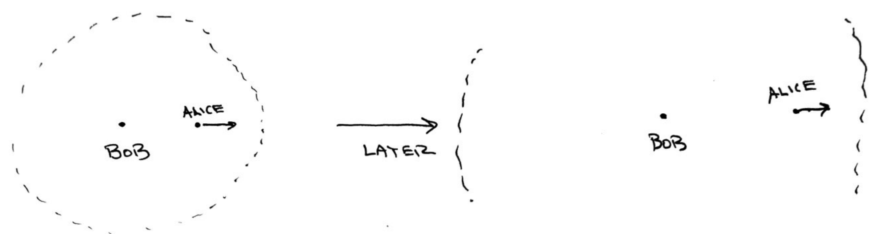


The speed of light is then

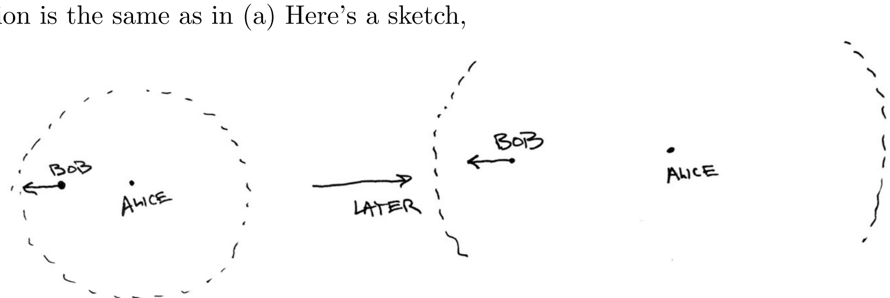
$$c = \frac{4D}{t} = \frac{4 \cdot 446 \text{ cm}}{62 \times 10^{-9} \text{ s}} \simeq 2.9 \times 10^{8} \text{ m/s}.$$

(Your answers might differ from mine.)

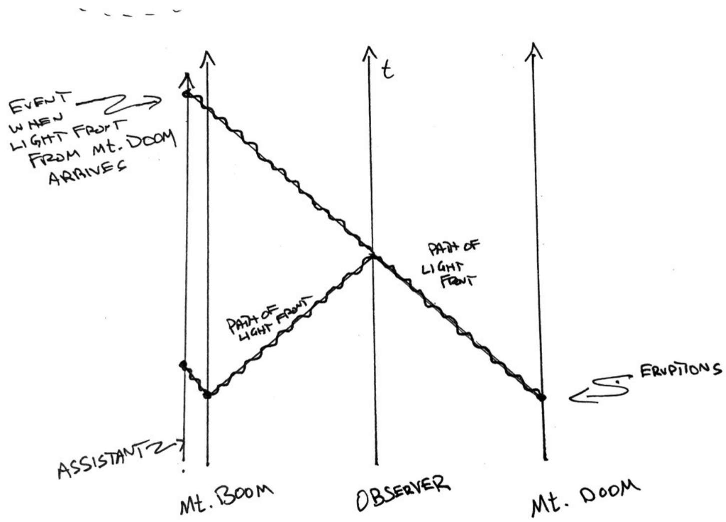
(9) Key point: Both Alice and Bob are the center of the light front in their frames.
   (a) The light has traveled further so the circle of the light front is now larger. The distance between Bob and Alice is now larger. Since Alice is traveling less than the speed of light, the gap between Alice and the light front is now also larger. Here's a sketch,



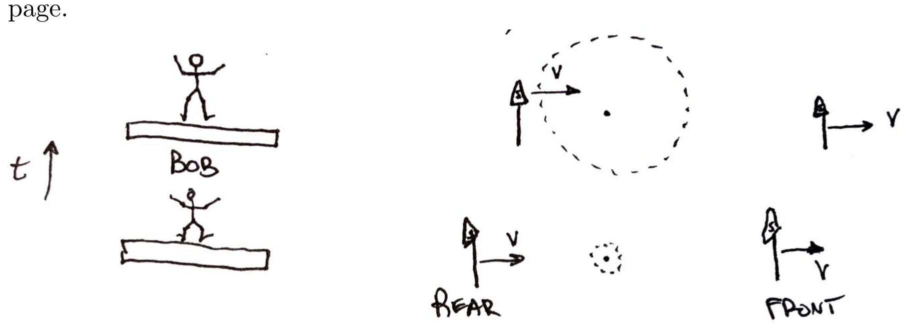
   (b) In Alice's frame Bob moves away in the opposite direction, to the left. Otherwise the situation is the same as in (a) Here's a sketch,



(10) The eruptions occur simultaneously in this frame. This follows from the fact that the observer in the middle sees the light arrive at the same event. Although from the assistant's point of view the light front from Mt. Boom's eruption arrives before the light front from Mt. Doom's eruption, the assistant concludes they erupt at the same time. This is due to the additional 500 km distance that separates the two volcanoes. The light from Mt. Doom has further to travel. Here's a spacetime diagram of the history,



(11) In Bob's reference frame, Alice's sled with sign posts moves to the left while the light front spreads out at constant speed in all directions. Here's a sketch of the history with time running up the page.



From this sketch we can see that the sign posts are illuminated at different times and the sign on the rear of Alice's sled is illuminated first.