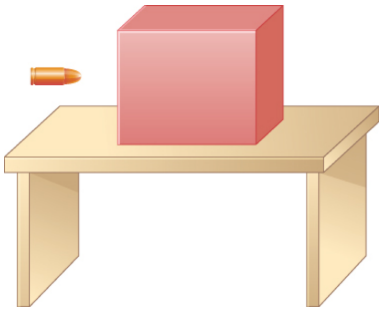
PHY 211 Recitation 16

March 6, 2020

1

The figure to the right shows a bullet of mass 200 g traveling horizontally towards the east with a speed of 400 m/s, which strikes a block of mass 1.5 kg that is initially at rest on a frictionless table. After striking the block, the bullet is embedded in the block and the block and the bullet move together as one unit. Treat this problem as one-dimensional in the horizontal direction.



Problem 1(a). Is momentum conserved in the collision? Why or why not?

Problem 1(b). Write an expression for the total momentum of the bullet and block just before the collision.

$p_i =$ _____

Problem 1(c). Write an expression for the total momentum of the bullet and block just after the collision.

$p_f =$ _____

Problem 1(d). What is the magnitude and direction of the velocity of the block/bullet combination immediately after the impact?

Problem 1(e). What is the magnitude and direction of the impulse by the block on the bullet?

Problem 1(f). What is the magnitude and direction of the impulse by the bullet on the block?

Problem 1(g). If it took 3 ms for the bullet to change the speed from 400 m/s to the final speed after impact, what is the average force the block applies to the bullet during this time?

Problem 1(h). Does it matter if the force was constant over the 3 ms?

2

An 1100 kg cannon oriented at an angle of 30° fires a 5 kg cannonball, and it leaves the cannon at 500 m/s.

Problem 2(a). Draw pictures of the setup just before and after the cannon fires.

Problem 2(b). Are there any external forces on the cannon and ball during the time the cannon is firing? If there are, what are they?

Problem 2(c). Is the momentum of the cannon plus the cannonball conserved in the horizontal direction? Why or why not? Does it depend on the surface?

Problem 2(d). Is momentum of the cannon plus the cannonball conserved in the vertical direction? Why or why not?

Problem 2(e). Determine the recoil velocity of the cannon, assuming the ground is frictionless, the instant after the cannon is fired. To do so, write expressions for the momentum just before and after the shot is fired. Then solve.

Problem 2(f). Now consider the effect of friction on the cannon. If the cannon takes 2 ms to fire, what is the impulse of friction on the cannon if the coefficient of kinetic friction is 0.3? How does that compare to the impulse in the horizontal direction of the ball on the cannon? *Hint: think carefully about the normal force on the cannon from the ground.*

3

Two figure skaters are coasting in the same direction, with the leading skater moving at 5.5 m/s and the trailing skating moving at 6.2 m/s. When the trailing skater catches up with the leading skater, he picks her up without applying any horizontal forces on his skates. Assume that coasting on the ice is frictionless. If the trailing skater is 50% heavier than the 50 kg leading skater, what is their speed after he picks her up? Consider the following steps:

(a) Is momentum conserved in the horizontal direction?

(b) Is momentum conserved in the vertical direction? *Note: this question is harder than it may seem, so think carefully about it.*

(c) Write expressions for the momentum of the pair of skaters just before and just after he picks her up.

(d) Solve for the final velocity.