

# Problem Set 4

## Momentum, Work, and Power

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### 1 Basic Problems

#### Problem 1 \*

Box A and box B are sliding towards each other on a frictionless surface. Box A, with a mass of 5kg, moves with a velocity 5m/s east, and Box B, with a mass of 10kg, moves with a velocity 3m/s east

- Calculate the momentum and kinetic energy of Box A
- Calculate the momentum and kinetic energy of Box B
- If the collision is elastic, find the speed of the two boxes after the collision

#### Problem 2 \*

A 6kg box is moving along a frictionless surface at a velocity of 10m/s. A fan is turned on, and the wind exerts a constant force of 5N on the box.

- How long does the fan need to blow to stop the box?
- What is the work done on the box by the fan?

#### Problem 3 \*

A 10kg dumbbell is dropped from a helicopter 150m above ground level. Find the final velocity of the ball

- Using kinematic equations
- Using conservation of energy

### 2 Going Further

#### Problem 4 \*\*

##### Sliding

A child is sliding out of control with velocity  $v_c$  across a frozen lake. He runs head-on into another child, initially at rest, with 3 times the mass of the first child, who holds on so that the two now slide together. What is the velocity of the couple after the collision in terms of  $v_c$ ?

#### Problem 5 \*\*

##### On the Road

A light car and a heavy truck have the same momentum. The truck weighs ten times as much as the car. If the car has kinetic energy  $k$ , write the truck's kinetic energy in terms of  $k$ .

#### Problem 6 \*

A block with a mass of 10kg and slides across a surface with an initial velocity of  $v_i = 20\text{m/s}$ , where the coefficient of kinetic friction is  $\mu_k = 0.1$ .

- How much work does friction do on the block before it stops?
- At  $t=5\text{s}$ , what is the kinetic energy of the block?

### 3 Challenge Problems

#### Problem 7 \*\*\*

##### Throwing Stones

Little 35-kg Taqwaan is sitting in a stationary 10kg wagon on level ground; the wagon can roll freely without friction. Taqwaan wants to propel the wagon forward without touching the ground. Conveniently, he is carrying two 5kg stones in the wagon.

1. He simultaneously throws both stones horizontally off the back of the wagon. The stones fly out of his hand with a speed of 8 m/s relative to Taqwaan. **How fast is the wagon moving forward afterwards?**
2. He stops and gets out of the wagon, gathers up the stones, and sits in the motionless wagon again. This time, he throws the stones out one at a time; each stone again leaves his hand at a speed of 8 m/s (relative to him!). **How fast is he moving after he has thrown the second stone?**

**Problem 8 \*\*\***

**On a Boat!**

You are on a 20 meter long boat, it weights 1000 kg, and you weigh 100 kg. Consider the system of you and the boat together. (Assume the boat slides on the water without friction, the boat's center of mass is at its center, and your center of mass is the same height as the boat's center of mass.)

1. If you are at one end of the boat, how far from the boat's center is the system's center of mass?
2. How far does the system's center of mass move (with respect to the water) if you walk from one end of the boat to the other?
3. Now consider the system of you, the boat, and the anchor of the boat. The anchor is 100 kg (ignore buoyancy of the anchor and weight of the rope from which it hangs) and is hanging in the water 10 meters directly below the center of the boat. Now you are at one end of the boat, how far is the boat's center from the center of mass of this system?