Phyx 135-1, Spring 2016, Quiz 3 **Name** _____

1) A baseball pitcher is standing on frictionless sled on a lake of ice. At first the sled is motionless, but as the pitcher practices throwing fastballs (by taking them out of a large basket on the sled), the sled begins to move. Suppose that the pitcher is throwing a fastball once every five seconds at a speed of 90 mph = 40.2 m/s, and that the baseballs have a mass of 145 g each. Suppose also that the sled + the pitcher + all the baseballs initially have a total mass of 132 kg, and that the sled ends up with a final speed of 6.00 m/s.

1a) (2 points) What is the average thrust (in newtons) being produced by the pitcher?

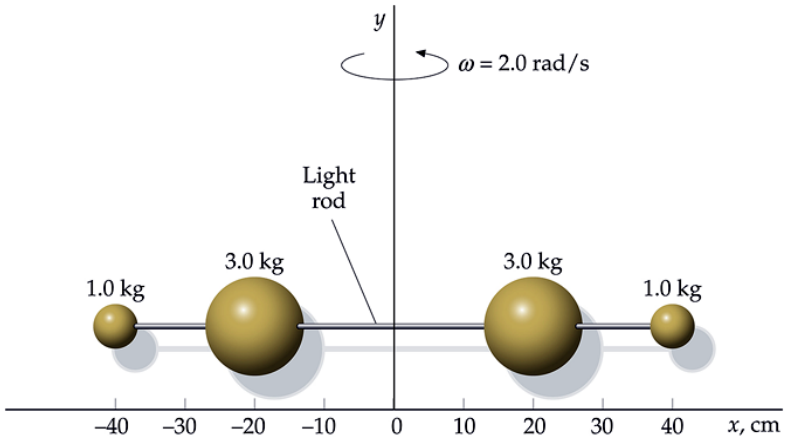
Solution
We have $F = (dm/dt)v = (0.145 \text{ kg} / 5 \text{ s})(40.2 \text{ m/s}) = 1.17 \text{ N}$.

1b) (8 points) How many baseballs did the pitcher have with him when he starting throwing?

Solution
We start with the simple rocket equation, $v_F = v_o \ln(1 + M_{fuel}/M_{rocket})$. Inserting numbers gives us $6.00 = (40.2) \ln(1 + M_{fuel} / M_{rocket})$, or $0.161 = M_{fuel} / M_{rocket}$.

We know that $M_{rocket} = 132 \text{ kg} - M_{baseballs}$, and the baseballs are our "fuel", so we have: $0.161 = M_{fuel} / (132 - M_{fuel})$, or $(0.161)(132 - M_{fuel}) = M_{fuel}$, or $21.25 = M_{fuel}(1 + 0.161)$, or $M_{fuel} = 18.3$ kg. At 0.145 kg per baseball, this gives us 18.3 / 0.145 = 126 baseballs.

2) (10 points) Calculate the kinetic energy of the rotating system shown at right. You may assume the smaller balls to have radii of 2 cm, and the larger balls to have radii of 5 cm. The moment of inertia of a sphere (through its CM) is $2MR^2 / 5$.



Solution
We have $E_k = \frac{1}{2} I\omega^2$. In this case we can use symmetry and the parallel axis theorem to write down I:
$\frac{1}{2} I_{axis} = (3)(0.2)^2 + (^2/_5)(3)(0.05)^2 + (1)(0.4)^2 + (^2/_5)(1)(0.02)^2$ means $I_{axis} = 0.566 \text{ kg m}^2$.

We then have $E_k = \frac{1}{2} (0.566)(2^2) = 1.13 \text{ J}$.