2017 F=ma Exam: Problem 8

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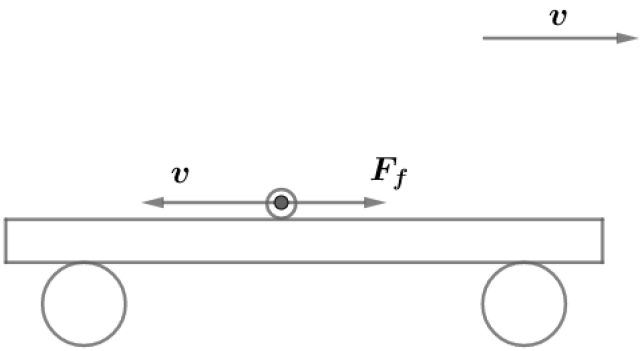
In addition to the increase in kinetic energy $dK/dt = \frac{1}{2}\rho v^2$ as we found in the previous problem, we also need to account for dissipation between the snow and the train. To compute the energy lost, let's move to the train frame moving at v to the right.



In this frame, the snow lands moving at v to the left and is slowed to rest. The energy lost to friction for a small piece of snow with mass dm is

$$dE_f = \frac{1}{2}(dm)v^2 = \frac{1}{2}(\rho\, dt)v^2$$

Thus, the rate of dissipation is

$$\frac{dE_f}{dt} = \frac{1}{2}\rho v^2$$

Therefore, the power required from the engine is

$$P = \frac{dK}{dt} + \frac{dE_f}{dt} = \rho v^2$$

so the answer is $\boxed{\text{E}}$.