2025Q4 **MASS & ENERGY BALANCES WITH FLOW RATES**

LEVEL 1 QUESTION (GRADES 5 – 8)

Solution: Mass Flow Rate

The problem states that a fan moves a mass of air (40 kg) over a period of 8 seconds.

Step 1: Use the Mass Flow Rate Equation

$$\dot{m} = \frac{Mass\ (kg)}{Time\ (s)}$$

$$\dot{m} = \frac{40\ kg}{8\ s}$$

$$\dot{m} = \frac{5\ kg}{1\ s}$$

$$\dot{m} = 5\ kg/s$$

This means that the fan moves 5 kg of air per second.

Step 2: Unit Conversion to the Required Units (lb/s)

The question requires the answer in pounds per second, instead of kilogram per second. Thus, a unit conversion is necessary. The hint states that 1kg = 2.2 lbs.

$$\dot{m} = \frac{5\cancel{kg}}{s} \times \frac{2.2\ lb}{1\ \cancel{kg}}$$

The kg units in the numerator and denominator will cancel out.

$$\dot{m} = \frac{11\ lb}{1\ s}$$

$$\dot{m} = 11\ lb/s$$

Final Answer: 11 pounds per second (11 lb/s)

LEVEL 2 QUESTION (GRADES 8 –11)

Solution: Volumetric Flow Rate -> Mass Flow rate

The problem requires calculating the volumetric flow rate, converting the volumetric flow rate to the mass flow rate using air density, followed by a unit conversion.

Step 1: Calculating Volumetric Flow Rate

Remember to convert minutes to seconds.

$$Q = \frac{24 m^3}{2 \cancel{min}} \times \frac{1 \cancel{min}}{60\ s}$$

$$Q = \frac{24\ m^3}{120\ s}$$

$$Q = \frac{1\ m^3}{5\ s}$$

$$Q = 0.2\ m^3/s$$

Step 2: Calculating Mass Flow Rate using Q and ρ

$$\dot{m} = \rho \times Q$$

$$\dot{m} = \frac{1.225\ kg}{\cancel{m^3}} \times 0.2 \frac{\cancel{m^3}}{s}$$

$$\dot{m} = 0.245\ kg/s$$

Step 3: Unit Conversion to the Required Units (lb/s)

$$\dot{m} = \frac{0.245 \cancel{kg}}{s} \times \frac{2.2\ lb}{1 \cancel{kg}}$$

$$\dot{m} = 0.539\ lb/s$$

Final Answer: 0.539 pounds per second (0.539 lb/s)