Answer on Question#39826, Physics, Mechanics | Kinematics | Dynamics

The speed of an airplane is 1200 ms^-1. The engines take in 80 kg of air per second and mix it with 40 kg of fuel. This mixture is expelled after it ignites and it moves at a velocity of 3000, ms^-1 relative to the airplane. Calculate the thrust of the engine.

Solution

Thrust is a reaction force described quantitatively by Newton's second and third laws. When a system expels or accelerates mass in one direction, the accelerated mass will cause a force of equal magnitude but opposite direction on that system.

From Newton's second law of motion a force F on an object is equal to the rate of change of its momentum

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt}.$$

In our case a force F can be expressed as

$$F = \frac{\Delta p}{\Delta t} = \frac{\Delta(mv)}{\Delta t}.$$

m_1 – mass of air per second, m_2 - mass of fuel per second.

$v_1 = 1200\,\frac{\text{m}}{\text{s}}$ - initial velocity of an air relative to the airplane, $v_2 = 3000\,\frac{\text{m}}{\text{s}}$ - final velocity of a fuel and an air relative to the airplane, initial velocity of a fuel relative to the airplane is 0.

Change of momentum in 1 second:

$$\Delta p = m_1(v_2 - v_1) + m_2(v_2 - 0) = (m_1 + m_2)v_2 - m_1 v_1.$$

The thrust of the engine:

$$F = \frac{\Delta p}{\Delta t} = \frac{(m_1 + m_2)v_2 - m_1 v_1}{\Delta t} = \frac{(80 + 40) \cdot 3000 - 80 \cdot 1200}{1} = 264\ kN.$$

Answer: $264\ kN$.