Answer on Question #47180 – Physics - Mechanics | Kinematics | Dynamics

The speed of an aeroplane is 1200m/s. 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 3000m/s relative to the aeroplane. 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 □ 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 □ 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.

$v_1 = 1200\frac{m}{s}$ - initial velocity of an air relative to the airplane,

v_2 = 3000 ms - 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:

$$F = \frac{\Delta p}{\Delta t} = (m_1 + m_2)v_2 - m_1 v_1 =$$

$$= (80kg + 40kg) \cdot 3000\frac{m}{s} - 80\ kg \cdot 1200\frac{m}{s} = 264\ kN$$

Answer: 264 kN.