Answer on Question #39994, Physics, Mechanics | Kinematics | Dynamics

The speed of an airplane is .ms12001− 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 1ms3000−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

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

We can find this force using mass that enters the airplane and mass that comes out of it:

$$F = \frac{dm_{\text{out}}}{dt} \cdot v_{\text{out}} - \frac{dm_{in}}{dt} \cdot v_{in},$$

where $\frac{dm_{in}}{dt}$ - the rate of change of mass that enters the airplane, $\frac{dm_{\text{out}}}{dt}$ - the rate of change of mass that comes out of airplane, $v_{in} = 1200\frac{m}{s}$ - velocity of an air which enters the airplane, $v_{\text{out}} = 3000\frac{m}{s}$ - velocity of a fuel and an air that comes out of the airplane.

$$\frac{dm_{in}}{dt} = 80\frac{kg}{s}; \frac{dm_{\text{out}}}{dt} = (80 + 40)\frac{kg}{s} = 120\frac{kg}{s}.$$

The thrust of the engine:

$$F = 120\frac{kg}{s} \cdot 3000\frac{m}{s} - 80\frac{kg}{s} \cdot 1200\frac{m}{s} = 264000\frac{kg \cdot m}{s^2} = 264\ kN.$$

Answer: $264\ kN$.