Important Impulse Momentum Equation and its Applications Formulas PDF

Formulas
Examples
with Units

List of 41
Important Impulse Momentum Equation and its Applications Formulas

1) Angular Momentum Principles Formulas

1.1) Change in Rate of Flow given Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$q_{flow} = \frac{\tau}{r2 \cdot V_2 - r1 \cdot V_1} \cdot \Delta$$

Example with Units

$$24.1373\,\text{m}^3/\text{s} = \frac{91\,\text{N*m}}{6.3\,\text{m} \cdot 61.45\,\text{m/s} - 2\,\text{m} \cdot 101.2\,\text{m/s}} \cdot 49\,\text{m}$$

1.2) Radial Distance r1 given Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$r1 = \frac{\left(r2 \cdot V_2 \cdot q_{flow}\right) - \left(\tau \cdot \Delta\right)}{q_{flow} \cdot V_1}$$

Example with Units

$$1.9896\,\text{m} = \frac{\left(6.3\,\text{m} \cdot 61.45\,\text{m/s} \cdot 24\,\text{m}^3/\text{s}\right) - \left(91\,\text{N*m} \cdot 49\,\text{m}\right)}{24\,\text{m}^3/\text{s} \cdot 101.2\,\text{m/s}}$$

1.3) Radial Distance r2 given Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$r2 = \frac{\left(\frac{\tau}{q_{flow}} \cdot \Delta\right) + r1 \cdot V_1}{V_2}$$

Example with Units

$$6.3172\,\text{m} = \frac{\left(\frac{91\,\text{N*m}}{24\,\text{m}^3/\text{s}} \cdot 49\,\text{m}\right) + 2\,\text{m} \cdot 101.2\,\text{m/s}}{61.45\,\text{m/s}}$$

1.4) Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$\tau = \left(\frac{q_{flow}}{\Delta}\right) \cdot \left(r2 \cdot V_2 - r1 \cdot V_1\right)$$

Example with Units

$$90.4824\,\text{N*m} = \left(\frac{24\,\text{m}^3/\text{s}}{49\,\text{m}}\right) \cdot \left(6.3\,\text{m} \cdot 61.45\,\text{m/s} - 2\,\text{m} \cdot 101.2\,\text{m/s}\right)$$

1.5) Velocity at Radial Distance r1 given Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$V_1 = \frac{q_{flow} \cdot r2 \cdot V_2 - (\tau \cdot \Delta)}{r1 \cdot q_{flow}}$$

Example with Units

$$100.6717\,\text{m/s} = \frac{24\,\text{m}^3\text{/s} \cdot 6.3\,\text{m} \cdot 61.45\,\text{m/s} - (91\,\text{N*m} \cdot 49\,\text{m})}{2\,\text{m} \cdot 24\,\text{m}^3\text{/s}}$$

1.6) Velocity at Radial Distance r2 given Torque Exerted on Fluid Formula

Evaluate Formula

Formula

$$V_2 = \frac{q_{flow} \cdot r1 \cdot V_1 + (\tau \cdot \Delta)}{q_{flow} \cdot r2}$$

Example with Units

$$61.6177\,\text{m/s} = \frac{24\,\text{m}^3\text{/s} \cdot 2\,\text{m} \cdot 101.2\,\text{m/s} + (91\,\text{N*m} \cdot 49\,\text{m})}{24\,\text{m}^3\text{/s} \cdot 6.3\,\text{m}}$$

2) Jet Propulsion Reaction of Jet Formulas

2.1) Jet Propulsion of Orifice Tank Formulas

2.1.1) Actual Velocity given Force exerted on Tank due to Jet Formula

Evaluate Formula

Formula

$$v = \sqrt{\frac{F \cdot [g]}{\gamma_f \cdot A_{Jet}}}$$

Example with Units

$$14.1397\,\text{m/s} = \sqrt{\frac{240\,\text{N} \cdot 9.8066\,\text{m/s}^2}{9.81\,\text{kN/m}^3 \cdot 1.2\,\text{m}^2}}$$

2.1.2) Area of Hole given Coefficient of Velocity for Jet Formula

Evaluate Formula

Formula

$$A_{Jet} = \frac{0.5 \cdot F}{\gamma_f \cdot h \cdot C_v^2}$$

Example with Units

$$1.1934\,\text{m}^2 = \frac{0.5 \cdot 240\,\text{N}}{9.81\,\text{kN/m}^3 \cdot 12.11\,\text{m} \cdot 0.92^2}$$

2.1.3) Area of Jet given Force exerted on Tank due to Jet Formula

Evaluate Formula

Formula

$$A_{Jet} = \frac{F}{\gamma_f \cdot \frac{v^2}{[g]}}$$

Example with Units

$$1.2068\,\text{m}^2 = \frac{240\,\text{N}}{9.81\,\text{kN/m}^3 \cdot \frac{14.1\,\text{m/s}^2}{9.8066\,\text{m/s}^2}}$$

2.1.4) Force exerted on Tank due to Jet Formula

Evaluate Formula

Formula

$$F = \gamma_f \cdot A_{Jet} \cdot \frac{v^2}{[g]}$$

Example with Units

$$238.6535\,\text{N} = 9.81\,\text{kN/m}^3 \cdot 1.2\,\text{m}^2 \cdot \frac{14.1\,\text{m/s}^2}{9.8066\,\text{m/s}^2}$$

2.1.5) Head over Jet Hole given Force exerted on Tank due to Jet Formula

Evaluate Formula

Formula

$$h = \frac{0.5 \cdot F}{\left(C_v^2\right) \cdot \gamma_f \cdot A_{Jet}}$$

Example with Units

$$12.0436\,\text{m} = \frac{0.5 \cdot 240\,\text{N}}{\left(0.92^2\right) \cdot 9.81\,\text{kN/m}^3 \cdot 1.2\,\text{m}^2}$$

2.1.6) Specific Weight of Liquid given Coefficient of Velocity for Jet Formula

Evaluate Formula

Formula

$$\gamma_f = \frac{0.5 \cdot F}{A_{Jet} \cdot h \cdot C_v^2}$$

Example with Units

$$9.7562\,\text{kN/m}^3 = \frac{0.5 \cdot 240\,\text{N}}{1.2\,\text{m}^2 \cdot 12.11\,\text{m} \cdot 0.92^2}$$

2.1.7) Specific Weight of Liquid given Force exerted on Tank due to Jet Formula

Evaluate Formula

Formula

$$\gamma_f = \left(\frac{F \cdot [g]}{A_{Jet} \cdot \left(v\right)^2}\right)$$

Example with Units

$$9.8653\,\text{kN/m}^3 = \left(\frac{240\,\text{N} \cdot 9.8066\,\text{m/s}^2}{1.2\,\text{m}^2 \cdot \left(14.1\,\text{m/s}\right)^2}\right)$$

2.2) Jet Propulsion of Ships Formulas

2.2.1) Absolute Velocity of Issuing jet given Propelling Force Formula

Evaluate Formula

Formula

$$V = [g] \cdot \frac{F}{W_{Water}}$$

Example with Units

$$2.3536\,\text{m/s} = 9.8066\,\text{m/s}^2 \cdot \frac{240\,\text{N}}{1000\,\text{kg}}$$

2.2.2) Absolute Velocity of Issuing Jet given Relative Velocity Formula

Evaluate Formula

Formula

$$V = V_r - u$$

Example with Units

$$6\,\text{m/s} = 10.1\,\text{m/s} - 4.1\,\text{m/s}$$

2.2.3) Area of Issuing Jet given Weight of Water Formula

Evaluate Formula

Formula

$$A_{Jet} = \frac{W_{Water}}{\gamma_f \cdot V_r}$$

Example with Units

$$10.0928\,\text{m}^2 = \frac{1000\,\text{kg}}{9.81\,\text{kN/m}^3 \cdot 10.1\,\text{m/s}}$$

2.2.4) Area of Issuing Jet given Work done by Jet on Ship Formula

Evaluate Formula

Formula

$$A_{Jet} = \frac{W \cdot [g]}{V \cdot u \cdot \gamma_f}$$

Example with Units

$$6.0955\,m^2 = \frac{150\,J \cdot 9.8066\,m/s^2}{6\,m/s \cdot 4.1\,m/s \cdot 9.81\,kN/m^3}$$

2.2.5) Efficiency of Propulsion Formula

Evaluate Formula

Formula

$$\eta = 2 \cdot V \cdot \frac{u}{(V + u)^2}$$

Example with Units

$$0.4823 = 2 \cdot 6\,m/s \cdot \frac{4.1\,m/s}{(6\,m/s + 4.1\,m/s)^2}$$

2.2.6) Efficiency of Propulsion given Head Loss due to Friction Formula

Evaluate Formula

Formula

$$\eta = 2 \cdot V \cdot \frac{u}{(V + u)^2 + 2 \cdot [g] \cdot h}$$

Example with Units

$$0.1449 = 2 \cdot 6\,m/s \cdot \frac{4.1\,m/s}{(6\,m/s + 4.1\,m/s)^2 + 2 \cdot 9.8066\,m/s^2 \cdot 12.11\,m}$$

2.2.7) Kinetic Energy of Water Formula

Evaluate Formula

Formula

$$KE = W_{Water} \cdot \frac{V_f^2}{2 \cdot [g]}$$

Example with Units

$$1274.6453\,J = 1000\,kg \cdot \frac{5\,m/s^2}{2 \cdot 9.8066\,m/s^2}$$

2.2.8) Propelling Force Formula

Evaluate Formula

Formula

$$F = W_{Water} \cdot \frac{V}{[g]}$$

Example with Units

$$611.8297\,N = 1000\,kg \cdot \frac{6\,m/s}{9.8066\,m/s^2}$$

2.2.9) Velocity of Jet Relative to Motion of Ship given Kinetic Energy Formula

Evaluate Formula

Formula

$$V_r = \sqrt{KE \cdot 2 \cdot \frac{[g]}{W_{body}}}$$

Example with Units

$$20.4124\,m/s = \sqrt{1274.64\,J \cdot 2 \cdot \frac{9.8066\,m/s^2}{60\,N}}$$

2.2.10) Velocity of Moving Ship given Relative Velocity Formula

Evaluate Formula

Formula

$$u = V_r - V$$

Example with Units

$$4.1\,m/s = 10.1\,m/s - 6\,m/s$$

3) Momentum Theory of Propellers Formulas

3.1) Diameter of Propeller given Thrust on Propeller Formula

Evaluate Formula

Formula

$$D = \sqrt{\left(\frac{4}{\pi}\right) \cdot \frac{Ft}{dP}}$$

Example with Units

$$14.5673\,\text{m} = \sqrt{\left(\frac{4}{3.1416}\right) \cdot \frac{0.5\,\text{kN}}{3\,\text{Pa}}}$$

3.2) Flow Velocity given Power Lost Formula

Evaluate Formula

Formula

$$V_f = V - \sqrt{\left(\frac{P_{loss}}{\rho_{Fluid} \cdot q_{flow} \cdot 0.5}\right)}$$

Example with Units

$$4.3824\,\text{m/s} = 6\,\text{m/s} - \sqrt{\left(\frac{15.7\,\text{W}}{0.5\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s} \cdot 0.5}\right)}$$

3.3) Flow Velocity given Rate of Flow through Propeller Formula

Evaluate Formula

Formula

$$V_f = \left(8 \cdot \frac{q_{flow}}{\pi \cdot D^2}\right) - V$$

Example with Units

$$-5.7117\,\text{m/s} = \left(8 \cdot \frac{24\,\text{m}^3\text{/s}}{3.1416 \cdot 14.56\,\text{m}^2}\right) - 6\,\text{m/s}$$

3.4) Flow Velocity given Theoretical Propulsive efficiency Formula

Evaluate Formula

Formula

$$V_f = \frac{V}{\frac{2}{\eta} - 1}$$

Example with Units

$$4\,\text{m/s} = \frac{6\,\text{m/s}}{\frac{2}{0.80} - 1}$$

3.5) Flow Velocity given Thrust on Propeller Formula

Evaluate Formula

Formula

$$V_f = -\left(\frac{Ft}{\rho_{Water} \cdot q_{flow}}\right) + V$$

Example with Units

$$5.9792\,\text{m/s} = -\left(\frac{0.5\,\text{kN}}{1000\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s}}\right) + 6\,\text{m/s}$$

3.6) Input Power Formula

Evaluate Formula

Formula

$$P_i = P_{out} + P_{loss}$$

Example with Units

$$52\,\text{J/s} = 36.3\,\text{W} + 15.7\,\text{W}$$

3.7) Output Power given Input Power Formula

Evaluate Formula

Formula

$$P_{out} = P_i - P_{loss}$$

Example with Units

$$36.3\,\text{W} = 52\,\text{J/s} - 15.7\,\text{W}$$

3.8) Output Power given Rate of Flow through Propeller Formula

Evaluate Formula

Formula

$$P_{out} = \rho_{Water} \cdot q_{flow} \cdot V_f \cdot \left(V - V_f \right)$$

Example with Units

$$120000\,\text{W} = 1000\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s} \cdot 5\,\text{m/s} \cdot \left(6\,\text{m/s} - 5\,\text{m/s} \right)$$

3.9) Power Lost Formula

Evaluate Formula

Formula

$$P_{loss} = \rho_{Fluid} \cdot q_{flow} \cdot 0.5 \cdot \left(V - V_f \right)^2$$

Example with Units

$$6\,\text{W} = 0.5\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s} \cdot 0.5 \cdot \left(6\,\text{m/s} - 5\,\text{m/s} \right)^2$$

3.10) Power Lost given Input Power Formula

Evaluate Formula

Formula

$$P_{loss} = P_i - P_{out}$$

Example with Units

$$15.7\,\text{W} = 52\,\text{J/s} - 36.3\,\text{W}$$

3.11) Rate of Flow given Power Lost Formula

Evaluate Formula

Formula

$$q_{flow} = \frac{P_{loss}}{\rho_{Fluid}} \cdot 0.5 \cdot \left(V - V_f \right)^2$$

Example with Units

$$15.7\,\text{m}^3\text{/s} = \frac{15.7\,\text{W}}{0.5\,\text{kg/m}^3} \cdot 0.5 \cdot \left(6\,\text{m/s} - 5\,\text{m/s} \right)^2$$

3.12) Rate of Flow through Propeller Formula

Evaluate Formula

Formula

$$Q = \left(\frac{\pi}{8} \right) \cdot \left(D^2 \right) \cdot \left(V + V_f \right)$$

Example with Units

$$915.7466\,\text{m}^3\text{/s} = \left(\frac{3.1416}{8} \right) \cdot \left(14.56\,\text{m}^2 \right) \cdot \left(6\,\text{m/s} + 5\,\text{m/s} \right)$$

3.13) Theoretical Propulsive Efficiency Formula

Evaluate Formula

Formula

$$\eta = \frac{2}{1 + \left(\frac{V}{V_f} \right)}$$

Example with Units

$$0.9091 = \frac{2}{1 + \left(\frac{6\,\text{m/s}}{5\,\text{m/s}} \right)}$$

3.14) Thrust on Propeller Formula

Evaluate Formula

Formula

$$Ft = \left(\frac{\pi}{4} \right) \cdot \left(D^2 \right) \cdot dP$$

Example with Units

$$0.4995\,\text{kN} = \left(\frac{3.1416}{4} \right) \cdot \left(14.56\,\text{m}^2 \right) \cdot 3\,\text{Pa}$$

3.15) Jet Velocity Formulas

3.15.1) Jet Velocity given Output Power Formula

Evaluate Formula

Formula

$$V = \left(\frac{P_{out}}{\rho_{Water} \cdot q_{flow} \cdot V_f} \right) + V_f$$

Example with Units

$$5.0003\,\text{m/s} = \left(\frac{36.3\,\text{W}}{1000\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s} \cdot 5\,\text{m/s}} \right) + 5\,\text{m/s}$$

3.15.2) Jet Velocity given Power Lost Formula

Evaluate Formula

Formula

$$V = \sqrt{\left(\frac{P_{loss}}{\rho_{Fluid} \cdot q_{flow} \cdot 0.5} \right)} + V_f$$

Example with Units

$$6.6176\,\text{m/s} = \sqrt{\left(\frac{15.7\,\text{W}}{0.5\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s} \cdot 0.5} \right)} + 5\,\text{m/s}$$

3.15.3) Jet Velocity given Theoretical Propulsive Efficiency Formula

Evaluate Formula

Formula

$$V = \left(\frac{2}{\eta} - 1 \right) \cdot V_f$$

Example with Units

$$7.5\,\text{m/s} = \left(\frac{2}{0.80} - 1 \right) \cdot 5\,\text{m/s}$$

3.15.4) Jet Velocity given Thrust on Propeller Formula

Evaluate Formula

Formula

$$V = \left(\frac{Ft}{\rho_{Water} \cdot q_{flow}} \right) + V_f$$

Example with Units

$$5.0208\,\text{m/s} = \left(\frac{0.5\,\text{kN}}{1000\,\text{kg/m}^3 \cdot 24\,\text{m}^3\text{/s}} \right) + 5\,\text{m/s}$$

Variables used in list of Impulse Momentum Equation and its Applications Formulas above

- A_{Jet} Cross Sectional Area of Jet *(Square Meter)*
- C_v Coefficient of Velocity
- **D** Diameter of Turbine *(Meter)*
- **dP** Change in Pressure *(Pascal)*
- **F** Force of Fluid *(Newton)*
- **Ft** Thrust Force *(Kilonewton)*
- **h** Impulse Height *(Meter)*
- **KE** Kinetic Energy *(Joule)*
- P_i Total Input Power *(Joule per Second)*
- P_{loss} Power Loss *(Watt)*
- P_{out} Output Power *(Watt)*
- **Q** Rate of Flow through Propeller *(Cubic Meter per Second)*
- q_{flow} Rate of Flow *(Cubic Meter per Second)*
- **r1** Radial Distance 1 *(Meter)*
- **r2** Radial Distance 2 *(Meter)*
- **u** Velocity of Ship *(Meter per Second)*
- **v** Actual Velocity *(Meter per Second)*
- **V** Absolute Velocity of Issuing Jet *(Meter per Second)*
- V_1 Velocity at Point 1 *(Meter per Second)*
- V_2 Velocity at Point 2 *(Meter per Second)*
- V_f Flow Velocity *(Meter per Second)*
- V_r Relative Velocity *(Meter per Second)*
- **W** Work done *(Joule)*
- W_{body} Weight of Body *(Newton)*
- W_{Water} Weight of Water *(Kilogram)*
- γ_f Specific Weight of Liquid *(Kilonewton per Cubic Meter)*
- **Δ** Delta Length *(Meter)*
- **η** Efficiency of Jet
- ρ_{Fluid} Density of Fluid *(Kilogram per Cubic Meter)*

Constants, Functions, Measurements used in list of Impulse Momentum Equation and its Applications Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[g]**, 9.80665 *Gravitational acceleration on Earth*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- Measurement: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Pressure** in Pascal (Pa) *Pressure Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Energy** in Joule (J) *Energy Unit Conversion*
- Measurement: **Power** in Watt (W), Joule per Second (J/s) *Power Unit Conversion*
- Measurement: **Force** in Newton (N), Kilonewton (kN) *Force Unit Conversion*
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m³/s) *Volumetric Flow Rate Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Torque** in Newton Meter (N*m) *Torque Unit Conversion*
- Measurement: **Specific Weight** in Kilonewton per Cubic Meter (kN/m³) *Specific Weight Unit Conversion*

- ρ_{Water} Water Density *(Kilogram per Cubic Meter)*
- τ Torque Exerted on Fluid *(Newton Meter)*

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