Important Traction Physics Formulas PDF

Formulas
Examples
with Units

List of 15
Important Traction Physics Formulas

1) Energy Available during Regeneration Formula

Evaluate Formula

Formula

$$E_R = 0.01072 \cdot \left(\frac{W_e}{W} \right) \cdot \left(v^2 - u^2 \right)$$

Example with Units

$$0.0021\,\text{W*h} = 0.01072 \cdot \left(\frac{33000\,\text{AT (US)}}{30000\,\text{AT (US)}} \right) \cdot \left(144\,\text{km/h}^2 - 111.6\,\text{km/h}^2 \right)$$

2) Energy Consumption for Overcoming Gradient and Tracking Resistance Formula

Evaluate Formula

Formula

$$E_G = F_t \cdot V \cdot T_{train}$$

Example with Units

$$3406.25\,\text{W*h} = 545\,\text{N} \cdot 150\,\text{km/h} \cdot 9\,\text{min}$$

3) Power Output of Motor using Efficiency of Gear Transmission Formula

Evaluate Formula

Formula

$$P = \frac{F_t \cdot V}{3600 \cdot \eta_{gear}}$$

Example with Units

$$7.6925\,\text{W} = \frac{545\,\text{N} \cdot 150\,\text{km/h}}{3600 \cdot 0.82}$$

4) Slip of Scherbius Drive given RMS Line Voltage Formula

Evaluate Formula

Formula

$$s = \left(\frac{E_b}{E_r} \right) \cdot \operatorname{mod}_{\underline{us}}\left(\cos\left(\theta \right) \right)$$

Example with Units

$$0.8354 = \left(\frac{145\,\text{V}}{156\,\text{V}} \right) \cdot \operatorname{mod}_{\underline{us}}\left(\cos\left(26° \right) \right)$$

5) Total Tractive Effort Required for Propulsion of Train Formula

Evaluate Formula

Formula

$$F_{train} = F_{or} + F_{og} + F$$

Example with Units

$$8175.5\,\text{N} = 8050\,\text{N} + 123\,\text{N} + 2.5\,\text{N}$$

6) Tractive Effort at Edge of Pinion Formula

Evaluate Formula

Formula

$$F_{pin} = \frac{2 \cdot \tau_e}{d_1}$$

Example with Units

$$64\,\text{N} = \frac{2 \cdot 4\,\text{N*m}}{0.125\,\text{m}}$$

7) Tractive Effort at Wheel Formula

Evaluate Formula

Formula

$$F_w = \frac{F_{pin} \cdot d_2}{d}$$

Example with Units

$$33.0323\,\text{N} = \frac{64\,\text{N} \cdot 0.80\,\text{m}}{1.55\,\text{m}}$$

8) Tractive Effort during Acceleration Formula

Evaluate Formula

Formula

$$F_\alpha = \left(277.8 \cdot W_e \cdot \alpha\right) + \left(W \cdot R_{sp}\right)$$

Example with Units

$$1.1E{+}6\,\text{N} = \left(277.8 \cdot 33000\,\text{AT (US)} \cdot 14.40\,\text{km/h*s}\right) + \left(30000\,\text{AT (US)} \cdot 9.2\right)$$

9) Tractive Effort on Driven Wheel Formula

Evaluate Formula

Formula

$$F_w = \frac{i \cdot i_o \cdot \left(\frac{\eta_{dl}}{100}\right) \cdot T_{pp}}{r_d}$$

Example with Units

$$33.2802\,\text{N} = \frac{2.55 \cdot 2 \cdot \left(\frac{5.2}{100}\right) \cdot 56.471\,\text{N*m}}{0.45\,\text{m}}$$

10) Tractive Effort Required during Free-Running Formula

Evaluate Formula

Formula

$$F_{free} = \left(98.1 \cdot W \cdot G\right) + \left(W \cdot R_{sp}\right)$$

Example with Units

$$52685.506\,\text{N} = \left(98.1 \cdot 30000\,\text{AT (US)} \cdot 0.52\right) + \left(30000\,\text{AT (US)} \cdot 9.2\right)$$

11) Tractive Effort Required for Linear and Angular Acceleration Formula

Evaluate Formula

Formula

$$F_{\omega\alpha} = 27.88 \cdot W \cdot \alpha$$

Example with Units

$$97580.0112\,\text{N} = 27.88 \cdot 30000\,\text{AT (US)} \cdot 14.40\,\text{km/h*s}$$

12) Tractive Effort Required to Overcome Effect of Gravity Formula

Evaluate Formula

Formula

$$F_g = 1000 \cdot W \cdot [g] \cdot \sin(\angle D)$$

Example with Units

$$44928.8618\,\text{N} = 1000 \cdot 30000\,\text{AT (US)} \cdot 9.8066\,\text{m/s}^2 \cdot \sin(0.3°)$$

13) Tractive Effort Required to Overcome Effect of Gravity given Gradient during up Gradient Formula

Evaluate Formula

Formula

$$F_{up} = 98.1 \cdot W \cdot G$$

Example with Units

$$44635.5051\,\text{N} = 98.1 \cdot 30000\,\text{AT (US)} \cdot 0.52$$

14) Tractive Effort Required to Overcome Train Resistance Formula

Evaluate Formula

Formula

$$F_{or} = R_{sp} \cdot W$$

Example with Units

$$8050.0009\,\text{N} = 9.2 \cdot 30000\,\text{AT (US)}$$

15) Tractive Effort Required while going down Gradient Formula

Evaluate Formula

Formula

$$F_{down} = \left(W \cdot R_{sp}\right) - \left(98.1 \cdot W \cdot G\right)$$

Example with Units

$$-36585.5042\,\text{N} = \left(30000\,\text{AT (US)} \cdot 9.2\right) - \left(98.1 \cdot 30000\,\text{AT (US)} \cdot 0.52\right)$$

Variables used in list of Traction Physics Formulas above

- ∠**D** Angle D *(Degree)*
- **d** Diameter of Wheel *(Meter)*
- d_1 Diameter of Pinion 1 *(Meter)*
- d_2 Diameter of Pinion 2 *(Meter)*
- E_b Back Emf *(Volt)*
- E_G Energy Consumption for Overcoming Gradient *(Watt-Hour)*
- E_r RMS Value of Rotor Side Line Voltage *(Volt)*
- E_R Energy Consumption during Regeneration *(Watt-Hour)*
- **F** Force *(Newton)*
- F_{down} Down Gradient Tractive Effort *(Newton)*
- F_{free} Free Run Tractive Effort *(Newton)*
- F_g Gravity Tractive Effort *(Newton)*
- F_{og} Gravity Overcome Tractive Effort *(Newton)*
- F_{or} Resistance Overcome Tractive Effort *(Newton)*
- F_{pin} Pinion Edge Tractive Effort *(Newton)*
- F_t Tractive Effort *(Newton)*
- F_{train} Train Tractive Effort *(Newton)*
- F_{up} Tractive Effort of Up Gradient *(Newton)*
- F_w Wheel Tractive Effort *(Newton)*
- F_α Acceleration Tractive Effort *(Newton)*
- $F_{\omega\alpha}$ Angular Accelration Tractive Effort *(Newton)*
- **G** Gradient
- **i** Gear Ratio of Transmission
- i_o Gear Ratio of Final Drive
- **P** Power Output Train *(Watt)*
- r_d Effective Radius of Wheel *(Meter)*
- R_{sp} Specific Resistance Train
- **s** Slip
- T_{pp} Torque Output from Powerplant *(Newton Meter)*

Constants, Functions, Measurements used in list of Traction Physics Formulas above

- constant(s): **[g]**, 9.80665
  Gravitational acceleration on Earth
- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions: **modulus**, modulus
  Modulus of a number is the remainder when that number is divided by another number.
- Functions: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Weight** in Ton (Assay) (US) (AT (US))
  Weight Unit Conversion
- Measurement: **Time** in Minute (min)
  Time Unit Conversion
- Measurement: **Speed** in Kilometer per Hour (km/h)
  Speed Unit Conversion
- Measurement: **Acceleration** in Kilometer per Hour Second (km/h*s)
  Acceleration Unit Conversion
- Measurement: **Energy** in Watt-Hour (W*h)
  Energy Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Torque** in Newton Meter (N*m)
  Torque Unit Conversion

- T_{train} Time Taken by Train *(Minute)*
- **u** Initial Velocity *(Kilometer per Hour)*
- **v** Final Velocity *(Kilometer per Hour)*
- **V** Velocity *(Kilometer per Hour)*
- **W** Weight of Train *(Ton (Assay) (US))*
- W_e Accelerating Weight of Train *(Ton (Assay) (US))*
- **α** Acceleration of Train *(Kilometer per Hour Second)*
- η_{dl} Efficiency of Driveline
- η_{gear} Gear Efficiency
- **θ** Firing Angle *(Degree)*
- τ_e Engine Torque *(Newton Meter)*

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