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Traction Physics Formulas

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List of 15 Traction Physics Formulas

Traction Physics

1) Energy Available during Regeneration

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

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

ex

$$0.002093W \cdot h = 0.01072 \cdot \left(\frac{33000AT \text{ (US)}}{30000AT \text{ (US)}} \right) \cdot \left((144\text{km/h})^2 - (111.6\text{km/h})^2 \right)$$

2) Energy Consumption for Overcoming Gradient and Tracking Resistance

$$fx \quad E_G = F_t \cdot V \cdot T_{\text{train}}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

ex

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

3) Power Output of Motor using Efficiency of Gear Transmission


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

[Open Calculator !\[\]\(235bfe13ebf007ce2eea9e689707fac7_img.jpg\)](#)

ex

$$7.692525W = \frac{545N \cdot 150\text{km/h}}{3600 \cdot 0.82}$$




4) Slip of Scherbius Drive given RMS Line Voltage 

$$fx \quad s = \left(\frac{E_b}{E_r} \right) \cdot \text{modulus}(\cos(\theta))$$

Open Calculator 

$$ex \quad 0.835418 = \left(\frac{145V}{156V} \right) \cdot \text{modulus}(\cos(26^\circ))$$

5) Total Tractive Effort Required for Propulsion of Train 

$$fx \quad F_{\text{train}} = F_{\text{or}} + F_{\text{og}} + F$$

Open Calculator 

$$ex \quad 8175.5N = 8050N + 123N + 2.5N$$

6) Tractive Effort at Edge of Pinion 

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

Open Calculator 

$$ex \quad 64N = \frac{2 \cdot 4N \cdot m}{0.125m}$$

7) Tractive Effort at Wheel 

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

Open Calculator 

$$ex \quad 33.03226N = \frac{64N \cdot 0.80m}{1.55m}$$


8) Tractive Effort during Acceleration 

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

Open Calculator 

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



9) Tractive Effort on Driven Wheel 

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

Open Calculator 

$$ex \quad 33.28024N = \frac{2.55 \cdot 2 \cdot \left(\frac{5.2}{100}\right) \cdot 56.471N \cdot m}{0.45m}$$

10) Tractive Effort Required during Free-Running 

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

Open Calculator 


$$ex \quad 52685.51N = (98.1 \cdot 30000AT \text{ (US)} \cdot 0.52) + (30000AT \text{ (US)} \cdot 9.2)$$

11) Tractive Effort Required for Linear and Angular Acceleration 

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

Open Calculator 


$$ex \quad 97580.01N = 27.88 \cdot 30000AT \text{ (US)} \cdot 14.40km/h \cdot s$$

12) Tractive Effort Required to Overcome Effect of Gravity 

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

Open Calculator 

$$ex \quad 44928.86N = 1000 \cdot 30000AT \text{ (US)} \cdot [g] \cdot \sin(0.3^\circ)$$

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

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

Open Calculator 

$$ex \quad 44635.51N = 98.1 \cdot 30000AT \text{ (US)} \cdot 0.52$$



14) Tractive Effort Required to Overcome Train Resistance

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

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$ex \quad 8050.001N = 9.2 \cdot 30000AT \text{ (US)}$$

15) Tractive Effort Required while going down Gradient

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

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$ex \quad -36585.504182N = (30000AT \text{ (US)} \cdot 9.2) - (98.1 \cdot 30000AT \text{ (US)} \cdot 0.52)$$



Variables Used











- $\angle D$ 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)
- 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)
- T_e Engine Torque (Newton Meter)



Constants, Functions, Measurements used

- **Constant:** [g], 9.80665 Meter/Second²
Gravitational acceleration on Earth
- **Function:** **cos**, cos(Angle)
Trigonometric cosine function
- **Function:** **modulus**, modulus
Modulus of number
- **Function:** **sin**, sin(Angle)
Trigonometric sine function
- **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 



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