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Traction Physics Formulas

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List of 15 Traction Physics Formulas

Traction Physics

1) Energy Available during Regeneration

Open Calculator

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

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

2) Energy Consumption for Overcoming Gradient and Tracking Resistance

Open Calculator

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

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

3) Power Output of Motor using Efficiency of Gear Transmission

Open Calculator

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

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

4) Slip of Scherbius Drive given RMS Line Voltage

Open Calculator

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

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

5) Total Tractive Effort Required for Propulsion of Train

Open Calculator

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

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

6) Tractive Effort at Edge of Pinion

Open Calculator

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

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

7) Tractive Effort at Wheel

Open Calculator

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

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

8) Tractive Effort during Acceleration

Open Calculator

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

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

9) Tractive Effort on Driven Wheel

Open Calculator

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

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

10) Tractive Effort Required during Free-Running

Open Calculator

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

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

11) Tractive Effort Required for Linear and Angular Acceleration

Open Calculator

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

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

12) Tractive Effort Required to Overcome Effect of Gravity

Open Calculator

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

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

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

Open Calculator

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

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

14) Tractive Effort Required to Overcome Train Resistance

Open Calculator

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

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

15) Tractive Effort Required while going down Gradient

Open Calculator

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

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

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)*
- τ_e Engine Torque *(Newton Meter)*

Constants, Functions, Measurements used

- Constant: **[g]**, 9.80665
  Gravitational acceleration on Earth
- Function: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Function: **modulus**, modulus
  Modulus of a number is the remainder when that number is divided by another number.
- Function: **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

Check other formula lists

- **Electric Traction Drives Formulas**
- **Electric Train Physics Formulas**
- **Mechanics of Train Movement Formulas**
- **Power & Energy Formulas**
- **Traction Physics Formulas**
- **Tractive Effort Formulas**

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