Simple Machines (p288)

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http://www.mdme.info/MEMmods/MEM23041A/dynamics/simple_machines/simple_machines.html

Velocity Ratio
VR = SE / SL
Velocity ratio = (Distance moved by EFFORT) / (Distance moved by LOAD)

Mechanical Advantage
ME = FL / FE
Mechanical Advantage = (Force of the LOAD) / (Force of the EFFORT)

Efficiency
\[ \eta = \frac{MA}{VR} \]
Efficiency = Mechanical Advantage / Velocity ratio.
In an ideal machine (with no friction), the efficiency = 1, also known as 100%.

The Law of a Machine (p293)
FE = -aFL + b
FE = Force of the EFFORT
FL = Force of the Load
a = slope of the graph
b = y intercept of the graph - where the line cuts the FE axis.

Limiting Efficiency
= 1 / (a.VR)
Efficiency = Mechanical Advantage / Velocity ratio
Q3: A force of 70N was applied over a distance of 1230mm which lifted a load of 468N through a distance of 106mm. (a) Find Velocity Ratio.

\[
VR = \frac{S_E}{S_L} = \frac{1230}{106} = 11.6038
\]

Q4: (cont) A force of 70N was applied over a distance of 1230mm which lifted a load of 468N through a distance of 106mm. (b) Find Mechanical Advantage.

\[
MA = \frac{F_L}{F_E} = \frac{468}{70} = 6.6857
\]

Q5: (cont) A force of 70N was applied over a distance of 1230mm which lifted a load of 468N through a distance of 106mm. (c) Find Work Input.

Energy in: \( W = FS = 70 \times 1.23 = 86.1 \text{ Joules} \)
Energy out: \( W = 468 \times 0.106 = 49.608 \text{ Joules} \)
Efficiency;

\[
\eta = \frac{MA}{VR} = \frac{6.6857}{11.6038} = 0.5762 \ (57.6\%)
\]

\[
\eta = \frac{W_{\text{out}}}{W_{\text{in}}} = \frac{49.608}{86.1} = 0.5762 \ (57.6\%)
\]

Q7: (cont) A force of 70N was applied over a distance of 1230mm which lifted a load of 468N through a distance of 106mm. (e) If friction was zero, what Effort would be needed?

This means efficiency = 100%
We could do with Work, or we could do by making \( MA = VR \).

Work method;
\[ Win = Wout = 49.608 \text{ J} \]
\[ W = FS, \text{ so } FS = 49.608 \text{ J} \]
\[ F = \frac{49.608}{1.23} = 40.3317 \text{ N} \]

**MA Method;**
\[ MA = VR = 11.6038 \]
\[ MA = \frac{F_L}{F_E} \]
\[ \text{So } F_E = \frac{F_L}{MA} = \frac{468}{11.6038} = 40.3316 \text{ N} \]

**Frictional Effort** (Force wasted against friction)
\[ \text{Frictional Effort} = 70 - 40.3316 = 29.6684 \text{ N} \]
Q9: A mystery machine has the following Law of a Machine: \( FE = 0.069 \times FL + 12 \) (Units are Newtons) (a) Find the MA when load is 2.3t.

\[
FL = 2300 \times 9.81 = 22563 \text{ N}
\]

\[
FE = 0.069 \times 22563 + 12 = 1567.26 \text{ N}
\]

\[
MA = \frac{FL}{FE} = \frac{22563}{1567.26} = 14.3965
\]

WORK = FS

POWER (LINEAR): \( P = \frac{FS}{t} = Fv \)

POWER (ROTARY): \( P = T\omega \)

Q22: INPUT: RPM=1448, torque=65Nm. OUTPUT: RPM=490, torque=140Nm. (a) Find input power

\[
P = T\omega
\]

\[
\omega = 1448 \times \frac{\pi}{30} = 151.634 \text{ rad/s}
\]

\[
P = 65 \times 151.634 = 9856.21 \text{ W}
\]
$\frac{F_t}{F_s} = e^{\mu \theta}$

$e = 2.718281828$ (Special number used in logarithm)

$\mu = \text{coeff of friction}$

**Calculator:**
- Casio 82: $e^1 = \text{Shift (ln)} , 1 ,$
- Casio 100: $e^1 = \text{Shift (ln)} , 1 ,$

**Example 24.4 p312**

Coeff = 0.25, angle = 150

Convert 150 to radians: $150\pi/180 = 2.617994 \text{ rad}$

Calculator: (shift)(ln) $^\theta$ (0.25*2.617994)

$2.71828^\theta(0.25*2.617994) = 1.924176$

$F_s = \frac{500}{1.924176} = 259.85149 \text{ N}$

Diam = 300mm

Radius = 0.15m,

Torque (t) = 0.15*500 = 75.0 Nm
Torque (s) = 0.15 * 259.85149 = - 38.97772 Nm
Net Torque = 75.0 - 38.97772 = 36.02228 Nm
V Belts

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\[
\frac{F_t}{F_s} = e^{(\mu \theta \sin \beta)}
\]

\[e \frac{\mu \theta}{\sin \beta}\]

\[e = 2.718281828 \text{ (Special number used in logarithms)}\]

\[\mu = \text{coeff of friction}\]

\[\theta = \text{angle of contact between the belt and the pulley (radians!)}\]

\[\beta = \text{half the angle between sides of the "V" groove. E.g. A typical belt has a wedge angle of about 40°, so take } \beta = 20° \text{ (except you must use radians of course).}\]

*Note: For a flat belt, } \beta = 90 \text{ degrees (which is } \pi/2 \text{ radians).}
**Square Cube Law**

**SQUARE/CUBE LAW**
Stress proportional to area \( f = \frac{F}{A} \)
Double the scale, area \(*4\).  

Mass (weight) proportional to volume
Double the scale, volume\(*8\)

Each time you double the scale, stress is doubled.

**Dynamic Similitude**
**Static** "
**Dimensional Analysis**