530.215 MBD, Spring 2009
Solutions for HW#2

Problem 1

SOLUTION (1.7D)

Known: Lockout/tagout procedures are discussed in 29 CFR 1910.147, which can be located at the website **http://www.osha.gov**.

Find: Write a paragraph explaining the procedure of lockout/tagout for machines or equipment.

Analysis: When service or maintenance is being preformed on a machine or equipment it should be locked and tagged out. These service or maintenance activities include lubrication, cleaning, or unjamming of a machine or equipment and making adjustments or tool changes, where the employee may be exposed to the unexpected energization or startup of the equipment or release of hazardous energy. A lockout device, either a key lock or combination lock, must be placed on the energy isolating device locking it into the safe position so that the equipment being controlled cannot be operated until the lockout device is removed. The tagout device should be placed on the isolating device, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Problem 3

SOLUTION (1.20)

Known: The parameters m, a, F, W, s, ω, T and $\dot{W}$ are identified.

Find: Check the dimensional homogeneity of the following equations: (a) $F = ma$, (b) $W = Fs$, (c) $\dot{W} = T\omega$.

Given Data:

m = mass
a = acceleration
F = force
W = work
s = distance
ω = angular velocity
T = torque
$\dot{W}$ = power

Analysis:

1. Let the dimensions of length, mass, and time be given by

length	[=] L
mass	[=] M
time	[=] t

Then,

m	[=] M
a	[=] L/t^2
F	[=] ML/t^2
W	[=] ML^2/t^2
s	[=] L
ω	[=] $1/t$
T	[=] ML^2/t^2
$\dot{W}$	[=] ML^2/t^3

2. (a) $F = ma$

$ML/t^2 = M(L/t^2) = ML/t^2$ ■

(b) $W = Fs$

$ML^2/t^2 = (ML/t^2)(L) = ML^2/t^2$ ■

(c) $\dot{W} = T\omega$

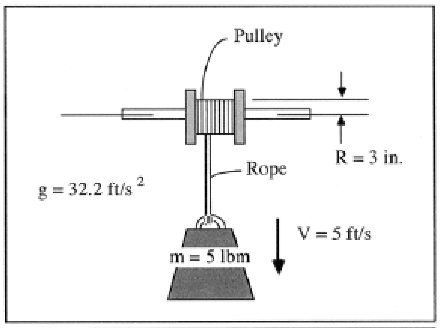
$(ML^2/t^2)(1/t) = ML^2/t^3$ ■

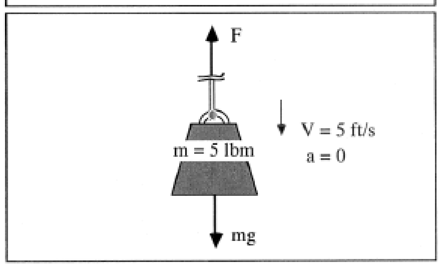
Problem 4

SOLUTION (1.32)
Known: A known mass attached to a rope wound around a pulley is falling with a constant velocity.

Find: Determine the power transmitted to the pulley and the rotational speed of the pulley.

Schematic and Given Data:





Assumptions:
1. Wind resistance is negligible.
2. Bearing friction is negligible.
3. Mass of the rope is negligible.
4. The acceleration of gravity is a constant.

Analysis:
1. First, draw a free body diagram of the mass and solve for the tension on the rope.

   $F - mg = ma$

   $F - mg = 0$

   $$F = mg = (5\text{ lbm})(32.2\text{ ft/s}^2)\left[\frac{1\text{ lb}}{32.2\text{ lbm ft/s}^2}\right] = 5\text{ lb}$$

2. From Eq. (1.3), $\dot{W} = \frac{2\pi\, n\, T}{33{,}000}$

   where $T = FR = 5\left(\frac{3}{12}\right) = 1.25\text{ lb·ft}$

   $$\omega = \frac{V}{R} = \frac{5}{\left(\frac{3}{12}\right)} = 20\text{ rad/s}$$

   $$n = \left|\frac{20\text{ rad}}{\text{s}}\right|\frac{60\text{ s}}{\text{min}}\left|\frac{1\text{ rev}}{2\pi\text{ rad}}\right| = 191.0\text{ rpm}$$ ■

3. $$\dot{W} = \frac{2\pi\,(191.0)(1.25)}{33{,}000} = 0.0455\text{ hp}$$

■

Comment: The power can also be calculated by using $\dot{W} = FV = (5\text{ lb})(5\text{ ft/s})/(550\text{ ft lb/s hp}) = 0.0455\text{ hp}$.

Problem 5

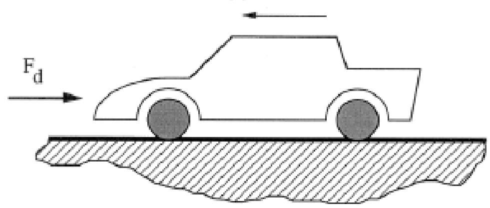
SOLUTION (1.36D)

Known: An automobile moving with velocity V is subjected to a known drag force.

Find: Calculate the power required to overcome the drag force. Compute and plot the power to overcome drag as a function of velocity.

Schematic and Given Data:

Part(a) V = 100 km/h
Part(b) V = 0 to 120 km/h



$F_d = C_d A (0.5)\, \rho V^2$

$C_d = 0.42$

$A = 2\ m^2$

$\rho = 1.23\ kg/m^3$

Assumption: The automobile velocity is constant.

Analysis:

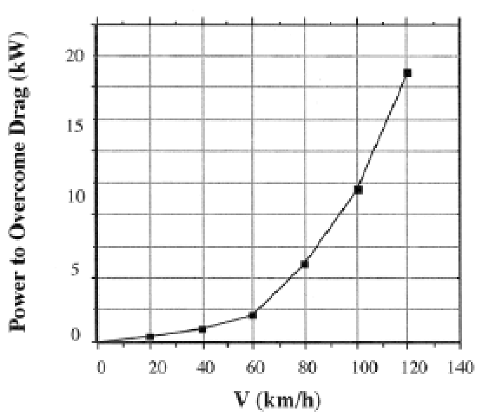
(a) For V = 100 km/h:

1. $V = \left|\dfrac{100\ km}{h}\right|\dfrac{1000\ m}{1\ km}\left|\dfrac{1\ h}{3600\ s}\right| = 27.78\ m/s$
2. Since $\dot{W} = F_d V$ and $F_d = C_d A \frac{1}{2} \rho V^2$,

$\dot{W} = C_d A \frac{1}{2} \rho V^3$

$\dot{W} = (0.42)(2)\left(\frac{1}{2}\right)(1.23)(27.78)^3 = 11.07\ kW$

(b) For V ranging from 0 to 120 km/h repeat steps 1 and 2. A plot is given in the following figure that shows **power to overcome drag** versus **vehicle velocity**.



Comment: Note that $\dot{W} = F_d V = C_d A \frac{1}{2} \rho V^2 \bullet V$ or $\dot{W} \sim V^3$

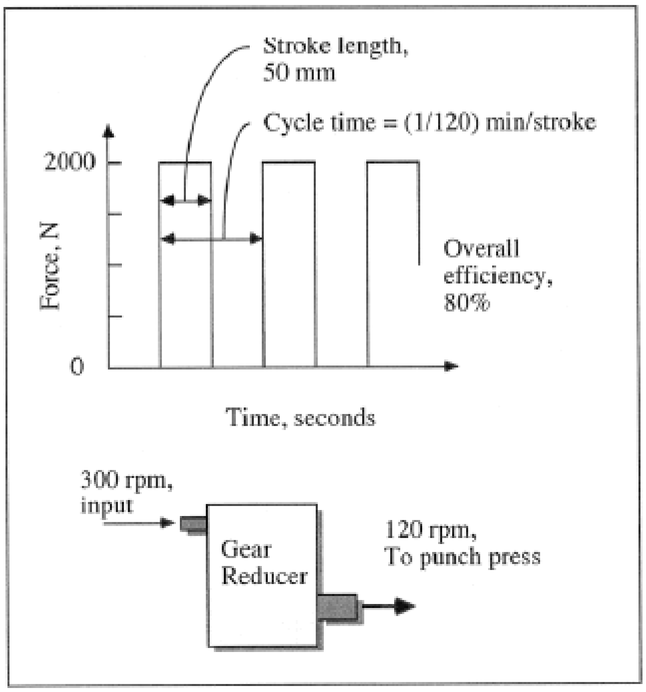
Problem 6

SOLUTION (1.42)

Known: A punch press provides a force of 2000 N through a stroke of 50 mm at a rate of 120 strokes per minute.

Find: Determine the (a) input shaft power and (b) torque.

Schematic and Given Data:



Assumption: Power out = 0.80 (Power in)

Analysis:

1. Power in = (Power out)/(eff) = (2000 N)(0.05 m/stroke)$\left(\frac{120 \text{ strokes}}{\text{min}} \frac{\text{min}}{60 \text{ sec}}\right)$ (1/0.8) = 250 N·m/s ■

2. From Eq. (1.2), $T = \frac{9549\,(\dot{W})}{n} = \frac{9549\,(0.25)}{300} = 8.0$ N·m ■