



## Length

$$1 \text{ ft} = 12 \text{ in} = 0.3048 \text{ m} = 1/3 \text{ yd}$$

$$1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 39.37 \text{ in} = 3.2808 \text{ ft}$$

$$1 \text{ mile} = 5280 \text{ ft} = 1609.3 \text{ m}$$

## Mass

$$1 \text{ kg} = 1000 \text{ g} = 2.2046 \text{ lbm}$$

$$1 \text{ lbm} = 16 \text{ oz} = 0.45359 \text{ kg}$$

$$1 \text{ slug} = 32.174 \text{ lbm}$$

## Temperature Values

$$(T/K) = (T/^{\circ}\text{R}) / 1.8$$

$$(T/K) = (T/^{\circ}\text{C}) + 273.15$$

$$(T/^{\circ}\text{C}) = [(T/^{\circ}\text{F}) - 32] / 1.8$$

$$(T/^{\circ}\text{R}) = 1.8(T/K)$$

$$(T/^{\circ}\text{R}) = (T/^{\circ}\text{F}) + 459.67$$

$$(T/^{\circ}\text{F}) = 1.8(T/^{\circ}\text{C}) + 32$$

## Temperature Differences

$$(\Delta T/^{\circ}\text{R}) = 1.8(\Delta T / \text{K})$$

$$(\Delta T/^{\circ}\text{R}) = (\Delta T/^{\circ}\text{F})$$

$$(\Delta T / \text{K}) = (\Delta T/^{\circ}\text{C})$$

## Volume

$$1 \text{ m}^3 = 1000 \text{ L} = 10^6 \text{ cm}^3 = 10^6 \text{ mL} = 35.315 \text{ ft}^3 = 264.17 \text{ gal}$$

$$1 \text{ ft}^3 = 1728 \text{ in}^3 = 7.4805 \text{ gal} = 0.028317 \text{ m}^3$$

$$1 \text{ gal} = 0.13368 \text{ ft}^3 = 0.0037854 \text{ m}^3$$

## Volumetric Flow Rate

$$1 \text{ m}^3/\text{s} = 35.315 \text{ ft}^3/\text{s} = 264.17 \text{ gal/s}$$

$$1 \text{ ft}^3/\text{s} = 1.6990 \text{ m}^3/\text{min} = 7.4805 \text{ gal/s} = 448.83 \text{ gal/min}$$

## Force

$$1 \text{ N} = 1 \text{ kg}\cdot\text{m}/\text{s}^2 = 0.22481 \text{ lbf}$$

$$1 \text{ lbf} = 1 \text{ slug}\cdot\text{ft}/\text{s}^2 = 32.174 \text{ lbm}\cdot\text{ft}/\text{s}^2 = 4.4482 \text{ N}$$

## Pressure

$$1 \text{ atm} = 101.325 \text{ kPa} = 1.01325 \text{ bar} = 14.696 \text{ lbf}/\text{in}^2$$

$$1 \text{ bar} = 100 \text{ kPa} = 10^5 \text{ Pa}$$

$$1 \text{ Pa} = 1 \text{ N}/\text{m}^2 = 10^{-3} \text{ kPa}$$

$$1 \text{ lbf}/\text{in}^2 = 6.8947 \text{ kPa} = 6894.7 \text{ N}/\text{m}^2$$

[lbf/in<sup>2</sup> often abbreviated as “psi” ]

## Energy

$$1 \text{ J} = 1 \text{ N}\cdot\text{m}$$

$$1 \text{ kJ} = 1000 \text{ J} = 737.56 \text{ ft}\cdot\text{lbf} = 0.94782 \text{ Btu}$$

$$1 \text{ Btu} = 1.0551 \text{ kJ} = 778.17 \text{ ft}\cdot\text{lbf}$$

$$1 \text{ ft}\cdot\text{lbf} = 1.3558 \text{ J}$$

## Energy Transfer Rate

$$1 \text{ kW} = 1 \text{ kJ}/\text{s} = 737.56 \text{ ft}\cdot\text{lbf}/\text{s} = 1.3410 \text{ hp} = 0.94782 \text{ Btu}/\text{s}$$

$$1 \text{ Btu}/\text{s} = 1.0551 \text{ kW} = 1.4149 \text{ hp} = 778.17 \text{ ft}\cdot\text{lbf}/\text{s}$$

$$1 \text{ hp} = 550 \text{ ft}\cdot\text{lbf}/\text{s} = 0.74571 \text{ kW} = 0.70679 \text{ Btu}/\text{s}$$

## Specific Energy

$$1 \text{ kJ}/\text{kg} = 1000 \text{ m}^2/\text{s}^2$$

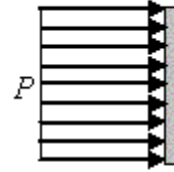
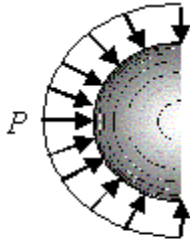
$$1 \text{ Btu}/\text{lbm} = 25037 \text{ ft}^2/\text{s}^2$$

$$1 \text{ ft}\cdot\text{lbf}/\text{lbm} = 32.174 \text{ ft}^2/\text{s}^2$$

**Problem 1** (12 pts)

- a) Consider a uniform pressure  $P$  acting on the left side of a hemisphere and a circular plate as shown in the figure. The hemisphere and circular plate have identical diameters,  $D_{\text{hemisphere}} = D_{\text{plate}}$ . How does the net force due to the pressure compare for the two cases? (Circle one.)

- i)  $F_a > F_b$
- ii)  $F_a < F_b$
- iii)  $F_a = F_b$
- iv) None of the above.



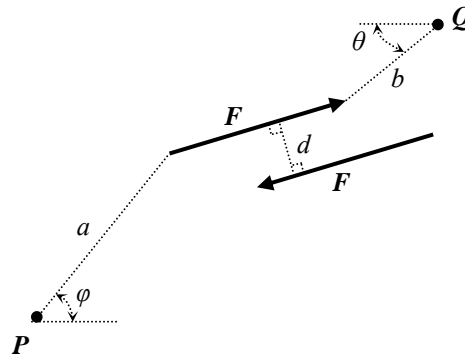
a) Hemisphere w/  $D = 1$  m

b) Circular plate w/  $D = 1$  m

- b) What are the *dimensions* of angular momentum? What is a typical set of *units* for angular momentum?

- c) Two forces, both with magnitude  $F$ , are oppositely directed and separated by a constant distance  $d$  as shown in the figure. How does the net moment due to these two forces about point  $P$  compare to that about point  $Q$ ? (Note:  $a > b$ ,  $\theta < \phi$ )

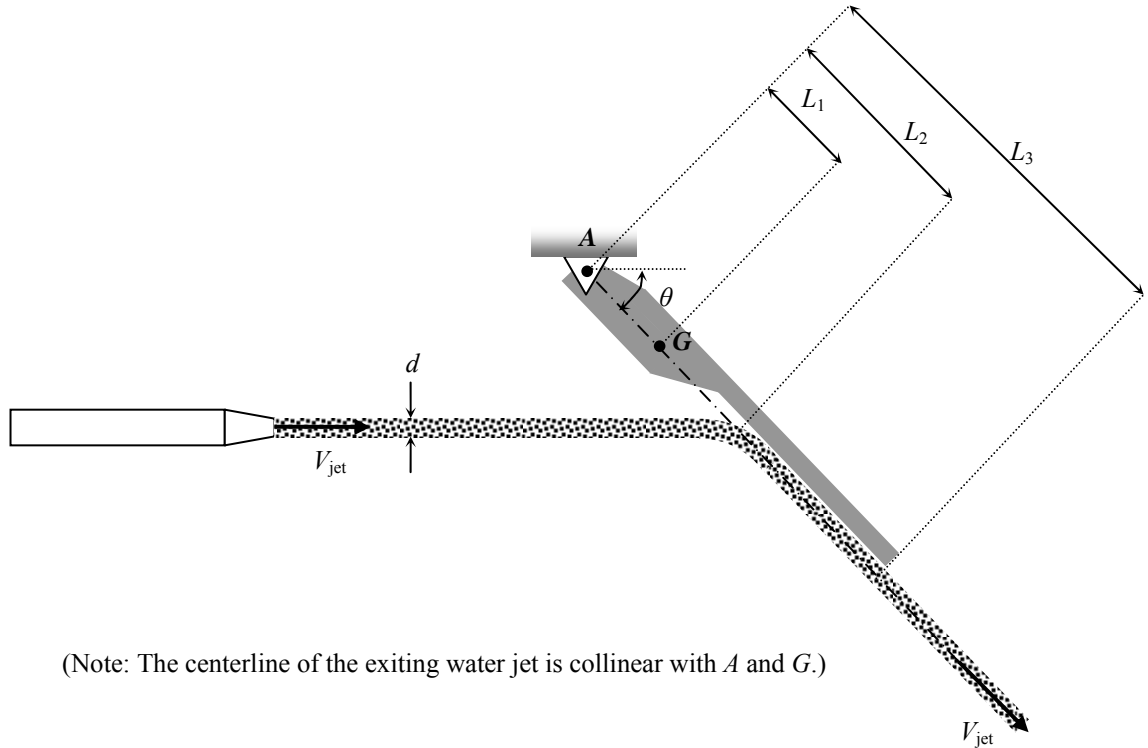
- i)  $M_P > M_Q$
- ii)  $M_P < M_Q$
- iii)  $M_P = M_Q$
- iv) None of the above.



**Problem 2** (24 pts)

A jet of water with density  $\rho$  hits a hinged flap with a mass  $m$  as shown in the figure. The velocity of the water of both the incoming and outgoing jet is  $V_{\text{jet}}$ . The incoming water jet is circular with a diameter  $d$ . Known dimensions are given in the figure.

- Find the angle  $\theta$  that the stationary flap makes with the horizontal. Express your answer in terms of the known quantities.
- Find the horizontal and vertical reaction forces at the pin connection  $A$ . You may assume that  $\theta$  is known from part (a).



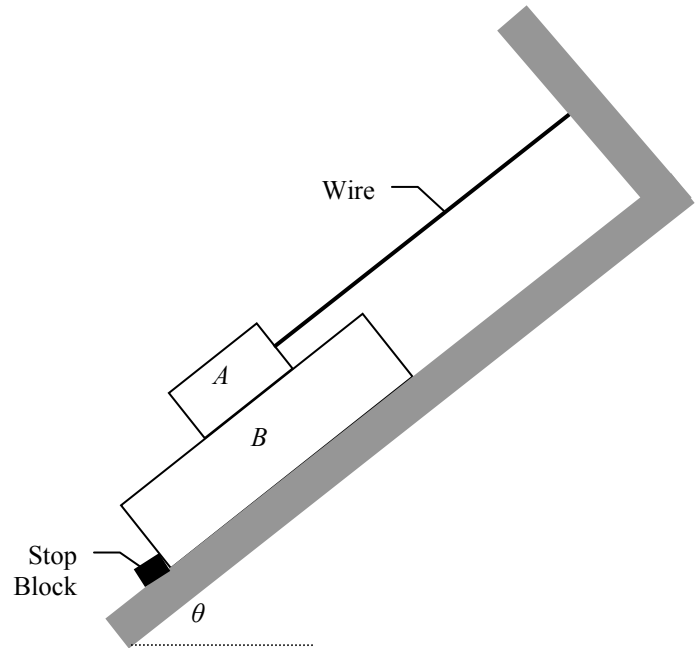
(Note: The centerline of the exiting water jet is collinear with  $A$  and  $G$ .)

**Problem 3** (24 pts)

Two blocks rest on an inclined plane with  $\theta = 35^\circ$  as shown in the figure. Block  $A$  has mass  $m_A = 13.5$  kg and block  $B$  has mass  $m_B = 40$  kg. The coefficients of static and kinetic friction between all surfaces are  $\mu_S = 0.3$  and  $\mu_k = 0.2$ , respectively. Initially the blocks are stationary and are supported by a stop block and fixed-length wire, as shown on the figure.

When the stop block is removed the block  $B$  immediately starts to move because the angle  $\theta$  is large enough to produce motion.

Find the acceleration of block  $B$  and the tension in the wire immediately after the stop block is removed.



**Problem 4** (40 pts)

Moo's Dairy has entered the annual Dairy Drag Race at the State Fair. His drag racer is a fully-loaded milk truck shown in the figure. When fully loaded, the milk truck weighs 5000 lbf. The truck is a *rear-wheel* drive vehicle, and the front tires provide negligible frictional drag when rolling.

The maximum traction between the tires and the road occurs when there is no slip between the tires and the road, i.e. the force between the road and the tires is due to static friction. The static coefficient of friction between the rubber tires and the concrete pavement is  $\mu_S = 0.80$ .

- (a) (16 pts) Determine the reactions between the tires and the road at points **A** and **B**, in lbf, when the truck is stationary.
- (b) (24 pts) Determine the maximum acceleration possible for the fully-loaded, rear-wheel drive milk truck, in  $\text{ft/s}^2$  or in  $g$ 's. Also determine the corresponding reactions at points **A** and **B**, in lbf. Is there any danger of the truck tipping under these conditions?

