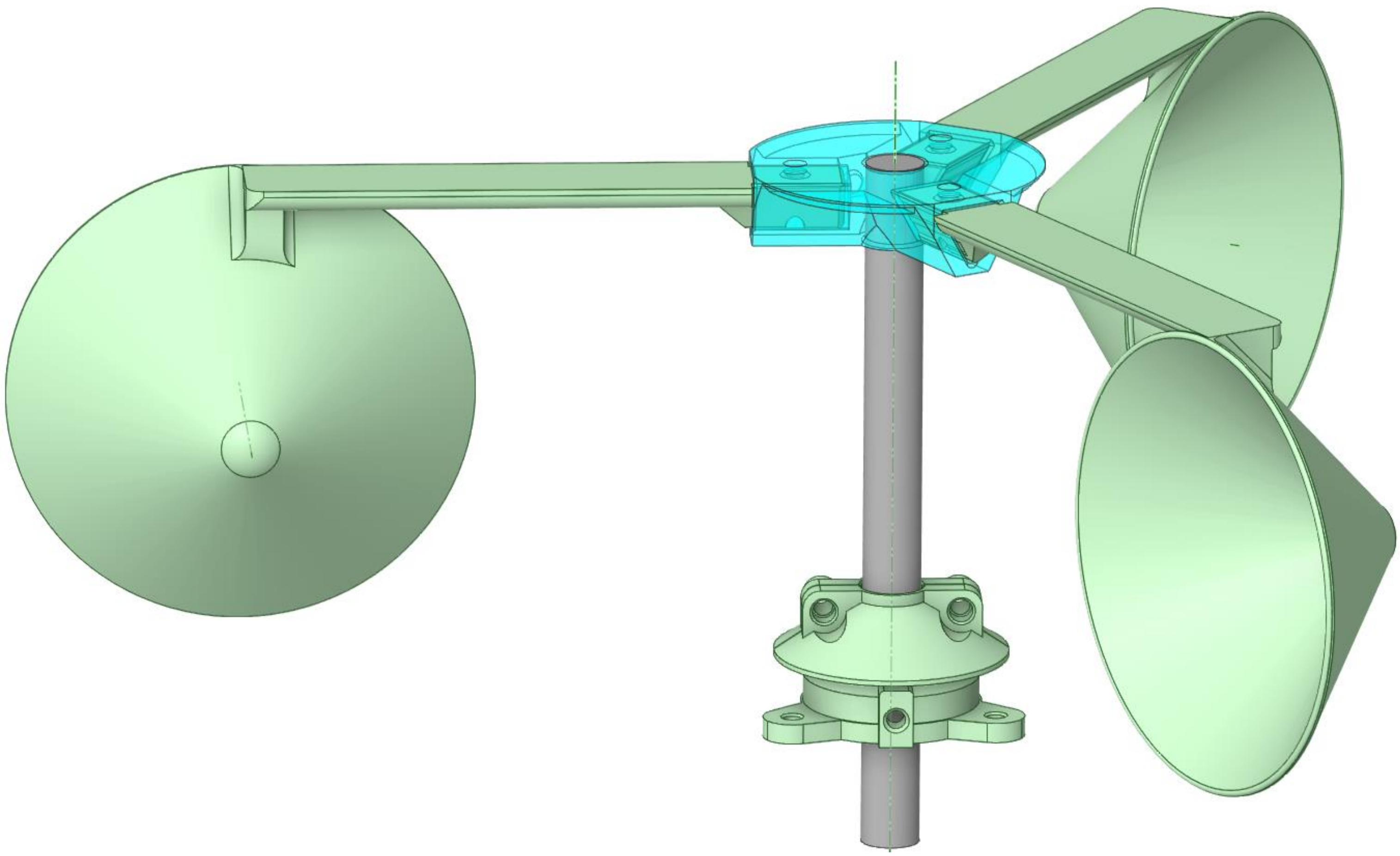
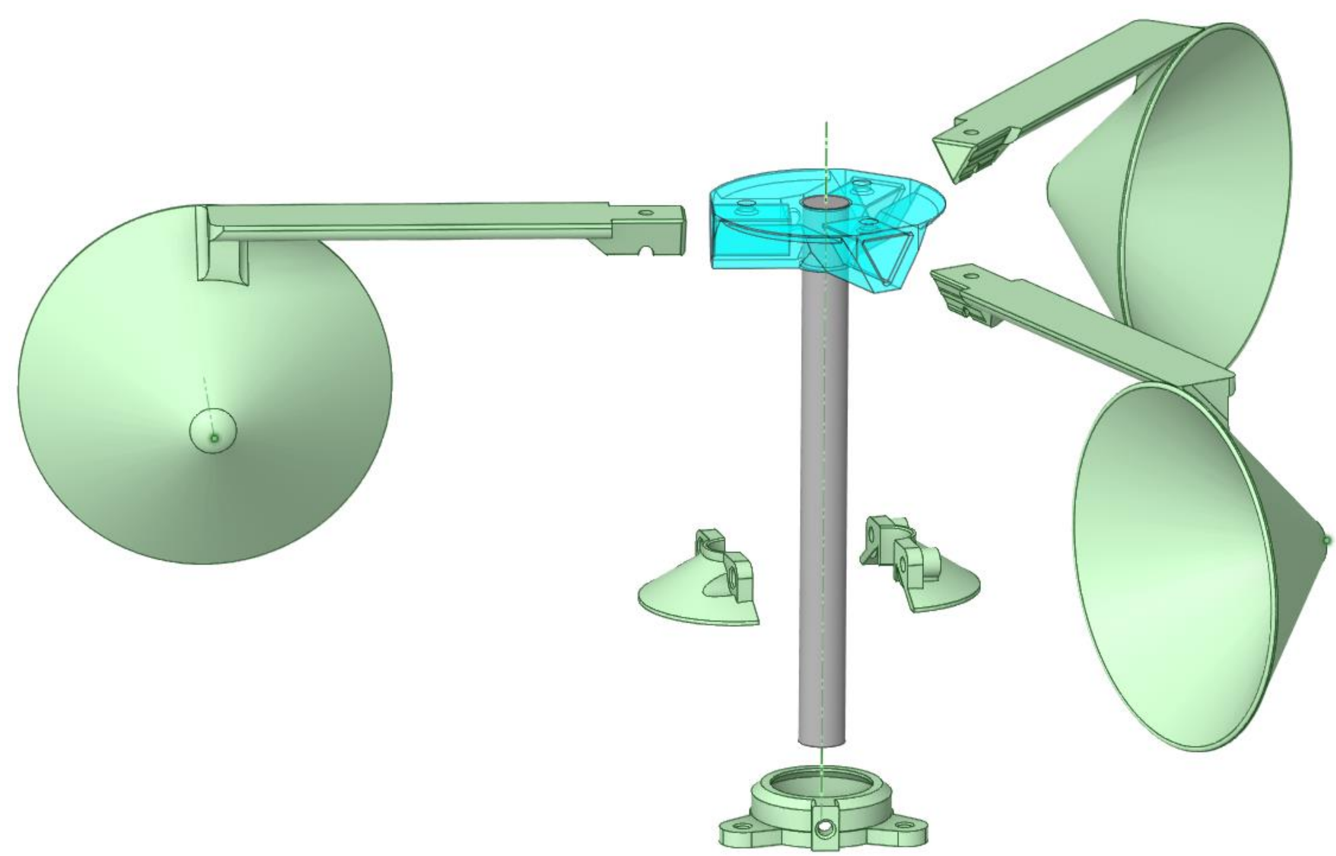
Anemometer (DesignSpark)



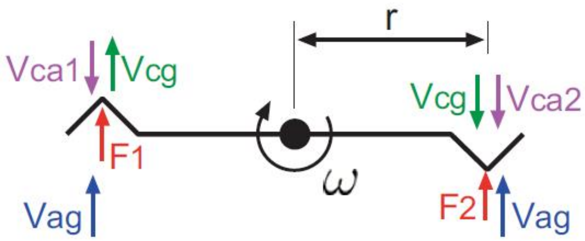
Exploded view (Screws not shown)



BOM (Bill of Materials)

Line	Qty	Type	Description	Part Num	Price
1	5	Screw	#2 3/8"L RoundHead Phillips BluntSheetMetal 18-8SS	92525A118	$5.97(100)
3	1	Screw	Set 4-40 1/8"L FlatTip 316SS	92158A119	$4.25(10)
6	1	Bearing	1/4"ID 5/8"OD 0.196"H DoubleShielded	R4ZZ	$7.69(10)
7	3	printPLA	CupWithArm		
8	1	printPLA	Hub		
9	1	printPLA	Skirt		
10	1	printPLA	BearingHolder		

2 cup anemometer analysis - Joe Barbetta (jbarbett@stevens.edu)



Two cups are used to simplify the analysis and to avoid the need for drag coefficient data for shapes at various angles with respect to flow. Bearing friction is assumed to be 0.

Vca1,2 = velocity of cup with respect to air
Vcg = velocity of cup with respect to ground
Vag = velocity of air with respect to ground
F1,F2 = force on cup

$$V_{ag} = V_{ca1} - V_{cg} \qquad V_{ag} = V_{cg} + V_{ca2}$$

$$V_{ca1} = V_{cg} + V_{ag} \qquad V_{ca2} = -V_{cg} + V_{ag}$$

$$F_D = \tfrac{1}{2}\rho v^2 DA$$ Force(drag) as function of fluid density, velocity, drag coefficient, area

$$F_1 = F_2$$ at equilibrium (no acceleration), no rotational friction

$$\tfrac{1}{2}\rho A D_{c1}(v_{ca1})^2 = \tfrac{1}{2}\rho A D_{c2}(v_{ca2})^2$$

$$D_{c1}(v_{ca1})^2 = D_{c2}(v_{ca2})^2$$

$$\frac{D_{c1}}{D_{c2}} = \left(\frac{V_{ca2}}{V_{ca1}}\right)^2$$

$$\sqrt{\frac{D_{c1}}{D_{c2}}} = \frac{v_{ca2}}{v_{ca2}} = \frac{-v_{cg}+v_{ag}}{v_{cg}+v_{ag}}$$

$$\sqrt{\frac{D_{c1}}{D_{c2}}}(v_{cg} + v_{ag}) = -v_{cg} + v_{ag}$$ now in terms of ground velocities

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$$D_R = \frac{D_{c1}}{D_{c2}} \qquad \sqrt{D_R} = \sqrt{\frac{D_{c1}}{D_{c2}}}$$ let's simplify equations by using ratio of draq coefficients

$$\sqrt{D_R}(V_{cg} + V_{ag}) = -V_{cg} + V_{ag}$$

$$\sqrt{D_R}V_{cg} + \sqrt{D_R}V_{ag} = -V_{cg} + V_{ag}$$

$$\sqrt{D_R}V_{cg} + V_{cg} = -\sqrt{D_R}V_{ag} + V_{ag}$$

$$V_{cg}(\sqrt{D_R} + 1) = V_{ag}(-\sqrt{D_R} + 1)$$

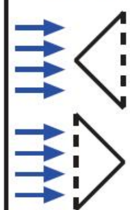
$$\frac{V_{cg}}{V_{ag}} = \frac{-\sqrt{D_R}+1}{\sqrt{D_R}+1} = \frac{1-\sqrt{D_R}}{1+\sqrt{D_R}}$$

$$V_{cg} = 2\pi r\omega \qquad \frac{2\pi r\omega}{V_{ag}} = \frac{1-\sqrt{D_R}}{1+\sqrt{D_R}}$$ now in terms of rotational velocity

$$\boxed{\frac{\omega}{V_{ag}} = \frac{1-\sqrt{D_R}}{1+\sqrt{D_R}}\frac{1}{2\pi r}}$$

Units must have the same length and time units, ie meters & seconds m/s, revolutions/s & m.

example with conical cups and 5cm radius



0.75

1.35

drag coefficients

$$\sqrt{D_R} = \sqrt{\frac{0.75}{1.35}} = 0.745$$

Dr = drag coefficient ratio

$$\frac{\omega}{V_{ag}} = \frac{1-0.745}{1+0.745}\frac{1}{2\pi 0.05m} = 0.465$$

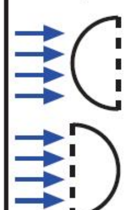
$$\omega = 0.465\,V_{ag}$$

rotational frequency at 10mph (4.47m/s)

$$\omega = 0.465 \text{ x } 4.47m/s = 2.079Hz$$

$$2.079Hz \text{ x } 60min/Hz = 124.7rpm$$

example with hemisperical cups and 5cm radius



0.38

1.42

drag coefficients

$$\sqrt{D_R} = \sqrt{\frac{0.38}{1.42}} = 0.517$$

Dr = drag coefficient ratio

$$\frac{\omega}{V_{ag}} = \frac{1-0.517}{1+0.517}\frac{1}{2\pi 0.05m} = 1.013$$

$$\omega = 1.013\,V_{ag}$$

rotational frequency at 10mph (4.47m/s)

$$\omega = 1.013 \text{ x } 4.47m/s = 4.528Hz$$

$$4.528Hz \text{ x } 60min/Hz = 271.7rpm$$