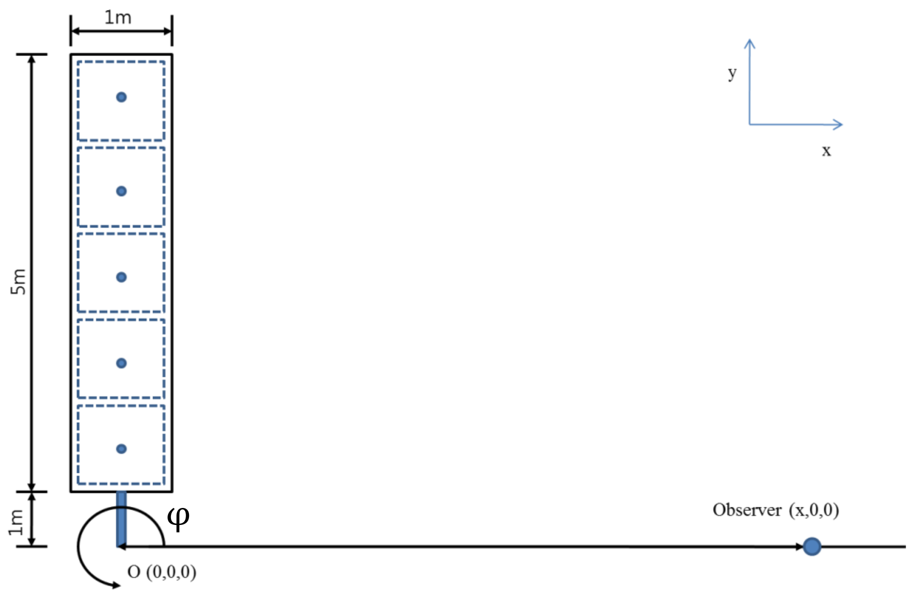
**Noise Engineering & Aeroacoustics** **Class 2019_Spring**
**Prof. Soogab Lee**
**(TA: Jonghui Kim)**

# TERM PROJECT#2 (Due 06/12)

1. In order to analyze rotating machinery noise, system could be designed as follows. Assume that there are **4 blades** with an angular gap of 90 degree and **5 noise sources** $P_i$ exist on each blade surface. Angular speed of rotor is **600RPM**, pitch angle is **5 degree**. Surface pressure $\mathbf{p_l}$ **is assumed to be** $\boldsymbol{\rho U^2}$**.** **(**Surface pressure is varying with rotor phase, so the surface pressure of each blade is different at a certain time.)

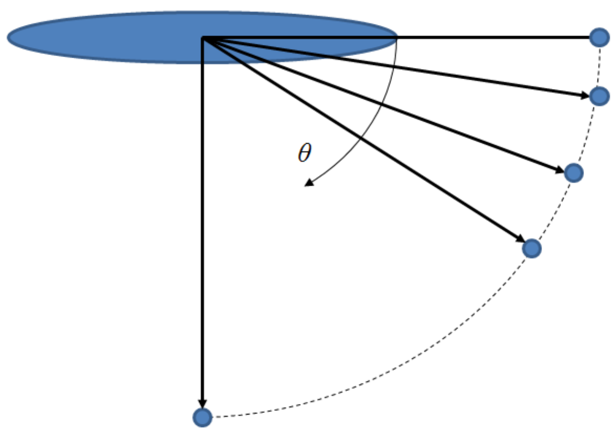
   - Caution: Rotor is operated in a standard condition (1atm, 15°C)



a) Solve and discuss for the time history of the **pressure** at the observer location. Observer is located in the same surface as rotor, and x is (20 + the last digit of your student ID e.g. 2014-12345 => x=25). (35 pts)

b) Obtain and discuss the time history of the pressure at the observer when the observer moves from (20,0,0) to (50,0,0) in the speed of **M=0.2**. (35 pts)

c) Assume that observer locates on the vertical (to the rotor) surface as in the figure. Obtain and discuss SPL by every 5 degree of θ and draw directivity pattern of rotating machinery noise. (30 pts)



# Appendix

## ※ Formula for analyzing rotor system

(Ref. K.S.Brenter, "Prediction of Helicopter noise discrete frequency noise", 1986)

- Thickness noise : monopole

$$4\pi p_T^{'} = \int_s \left[ \frac{\rho_0 \dot{\vec{v}}_n}{r\left(1-M_r\right)^2} \right]_{ret} dS + \int_S \left[ \frac{\rho_0 v_n \left( \dot{\vec{M}} \cdot \vec{r} + c_0 M_r - c_0 M^2 \right)}{r^2 \left(1-M_r\right)^3} \right]_{ret} dS$$

- Loading noise : dipole

$$4\pi p_L^{'} = \frac{1}{c_0} \int_s \left[ \frac{\dot{p}_l \hat{r}}{r\left(1-M_r\right)^2} \right]_{ret} dS + \int_s \left[ \frac{p_{l.r} - (p_l \cdot \hat{n}) \cdot \vec{M}}{r^2\left(1-M_r\right)^2} \right]_{ret} dS + \frac{1}{c_0} \int_S \left[ \frac{p_{l,r} \left( \dot{\vec{M}} \cdot \vec{r} + c_0 M_r - c_0 M^2 \right)}{r^2 \left(1-M_r\right)^3} \right]_{ret} dS$$

- Overall noise:

$$p^{'}\left(\vec{x},t\right) = p_T^{'}(\vec{x},t) + p_L^{'}(\vec{x},t)$$

$[\,]_{ret}$ : retarded time

$M_r$ : relative mach number

M : Mach number

r : distance between source and observer

$p_l$ : surface pressure

$v_n$ : velocity normal to blade surface

(determined by angular velocity & pitch angle)