GIVEN: TURBINE POWER CURVE & ROTATION RATE AS A FUNCTION OF WIND SPEED AS WELL AS TURBINE DIAMETER (52m)

FIND: (a) COEFFICIENT OF PERFORMANCE
(b) PLOT COP VS. TIP SPEED RATIO. INCLUDE BETZ & GLAUERT CURVES
(c) COMMENT ON THE RESULT

SOLUTION: (a) POWER COEFFICIENT GIVEN BY

$$C_p = \frac{P}{\frac{1}{2}\rho V^3 A} \qquad \rho = 1.23 \frac{kg}{m^3} \text{ Sea Level}$$

A ≡ AREA OF TURBINE

$$D = 52\ m$$

$$A = \frac{\pi D^2}{4} = 2,124\ m^2$$

SEE ATTACHED PLOT FOR C_p VS. V

(b) THE TIP SPEED RATIO IS GIVEN BY

$$\lambda = \frac{V_{TIP}}{V}$$

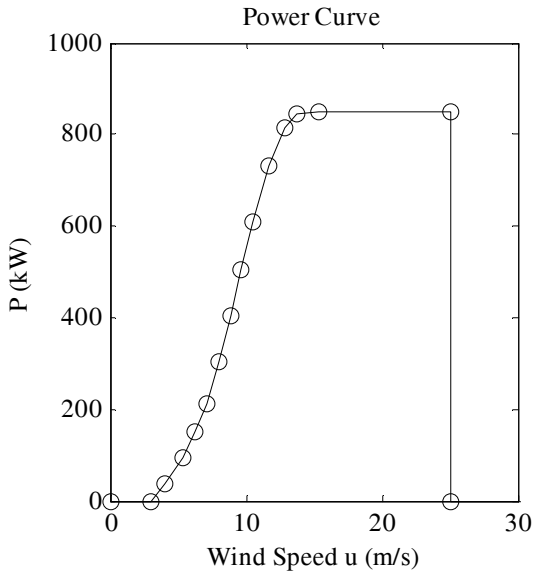
V_{TIP} MUST BE DETERMINED FROM ROTATION RATE

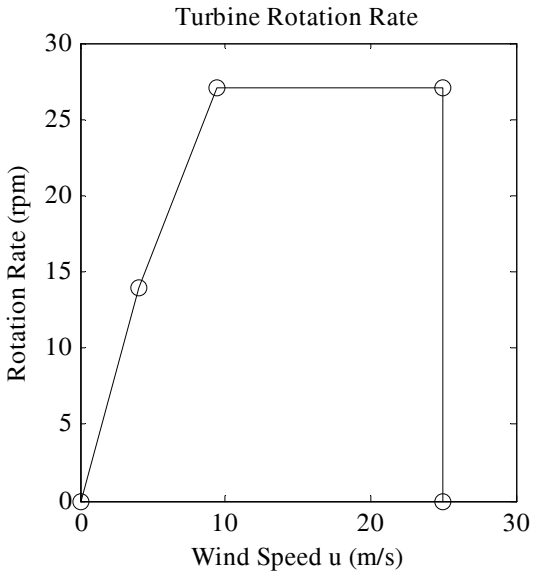
$$V_{TIP} = (rpm)/60 \frac{sec}{min} * 2\pi \frac{RAD}{REV} * R$$

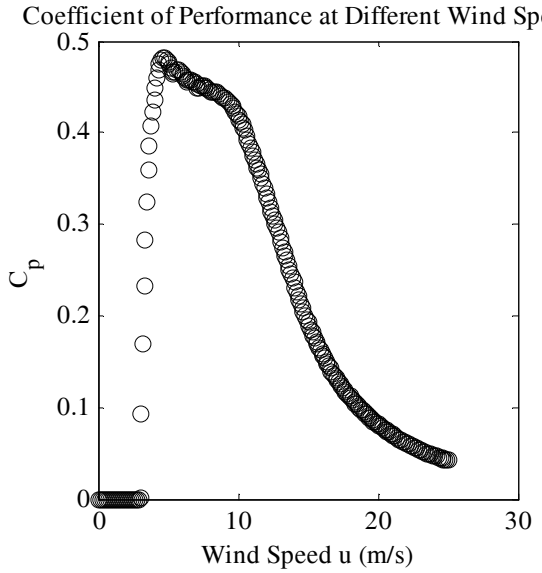
(R: TIP RADIUS)

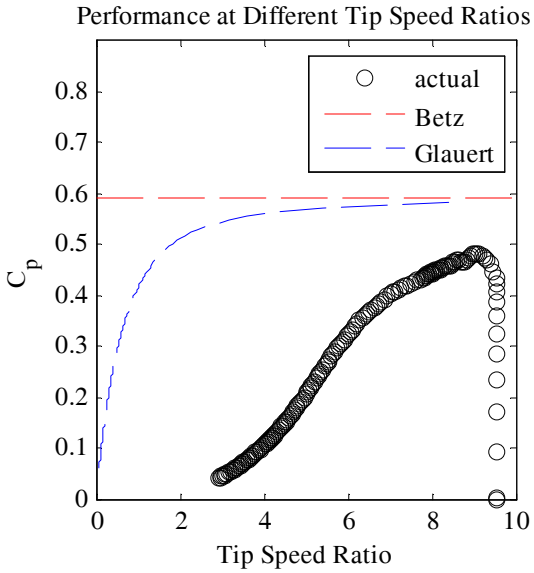
SEE ATTACHED PLOTS FOR RESULTS.

(c) THE RESULTS INDICATE THAT THE PEAK VALUE OF C_p HAPPENS SHORTLY AFTER CUT-IN VELOCITY WHICH CORRESPONDS TO A HIGH TIP SPEED RATIO. THE C_p ONLY DECREASES SLOWLY UP TO THE DESIGN WIND SPEED (12-14 m/s) WHERE POWER IS A MAXIMUM. THIS HAPPENS AT A $\lambda \sim 8$. FOR HIGHER WIND VELOCITIES, λ DROPS AS DOES C_p BECAUSE NO MORE POWER IS PRODUCED EVEN THOUGH THERE IS MORE POWER IN THE WIND.


Power Curve
P (kW)
Wind Speed u (m/s)
0
200
400
600
800
1000
0
10
20
30


Turbine Rotation Rate
Rotation Rate (rpm)
Wind Speed u (m/s)
0
5
10
15
20
25
30
0
10
20
30


Coefficient of Performance at Different Wind Speed
C_p
Wind Speed u (m/s)
0
0.1
0.2
0.3
0.4
0.5
0
10
20
30


Performance at Different Tip Speed Ratios
actual
Betz
Glauert
C_p
Tip Speed Ratio
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
2
4
6
8
10