Solution

Question 3

a)

To model the system we must first derive an equation to find the torque generated by the turbine blades as this will be the **Input torque:**

Multiply the Mass by the radius to give the 1st moment of mass = rm
Multiply again by the radius to get the 2nd moment of mass = r^2m
This is the moment of inertia I

$Ta = I.\alpha$ where α is the angular acceleration.

Angular acceleration is given as

$$\alpha = \frac{\Delta\boldsymbol{\omega}}{\Delta\boldsymbol{time}}$$

Angular velocity ω will be a tangential product of the wind pressure P acting on the turbine blades.

The power generated will be given by:

$$Power = Torque.\boldsymbol{\omega}$$

Now consider the input torque T acting on section L1 and L2 and L3:

"Subjected to an applied torque T, the power transmitted will have the following conditions: Equilibrium: Applied torque T= Ta=Tb i.e the torque is the same in each section of the shaft.

So the applied torque T acts on sections L1 and L2, Begin by finding the polar second moment of area for each section L1-L3":

$$J = \frac{\pi D^4}{32}$$

The max shear stress is found acting at the outer surface of each Radii (1-3) , in other words at the Rmax position.This stress is gound with the torsion equation:

$$\tau_{L1} = \frac{TR_1}{J_1}$$

$$\tau_{L2} = \frac{TR_2}{J_3}$$

$$\tau_{L1} = \frac{TR_1}{J_3}$$

$$(For\ all\ three\ the\ input\ torque\ T\ will\ be\ the\ same\ ammount)$$

It stands to reason therefore that the greatest shear stress will be found at L3, the smallest shaft.

"*Using the torsion equation and noting that the max stress τ occurs at the maximum radius,i.e at the outer surface":*

$$\frac{T}{J} = \frac{\tau}{R} \to Tmax = \frac{\tau J}{R}$$

So therefore $Power = \frac{\tau J}{R}.\boldsymbol{\omega}$

Apply this formula in sequence for each section L1-L3 to find the final power for section L3.

Now account for the armature housing which produces a dampening effect of constant **C**:
The resistive torque will be known as Tr:

Net power transmission = $(\frac{\tau J}{R} - Tr).\omega$