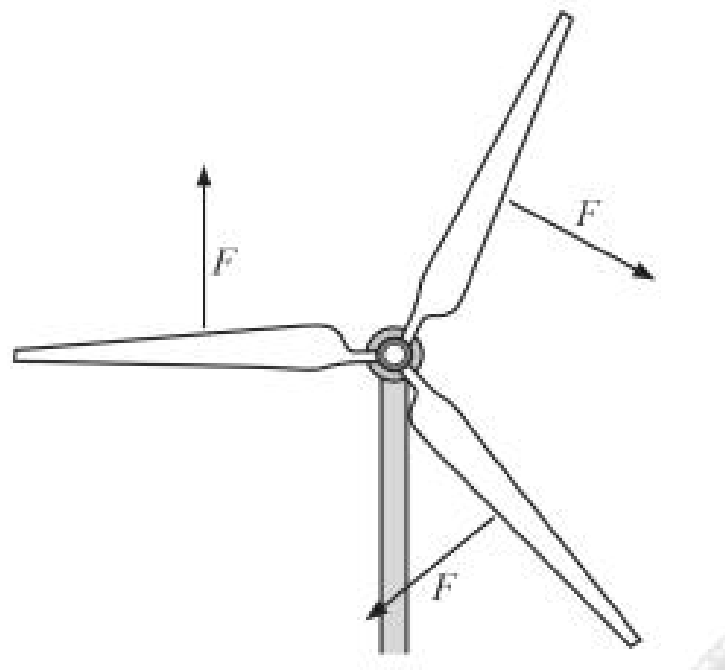


Wind turbines

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How do wind turbines work?

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Wind turbine blades vary in length between 40 and 80 m.

A major problem with wind turbines is varying wind speed. The input power must match the output power. The output power depends entirely on rotational speed and torque so how do we keep rotational frequency constant when wind speed keeps changing? The solution is mechanical. The operators use blade pitch control which changes the angle of the blades and reduces the surface area facing the wind. This reduces the amount of energy collected by the turbine and controls the force applied to each blade.

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How the pitch is altered to control the rotational speed.

Each blade experiences a gravitational torque. If the clockwise and anticlockwise gravitational torques add up to zero, the turbine is considered balanced. A symmetrical three-blade turbine is considered balanced at all times.

- (a) (i) Explain why a step-up transformer is used to increase the voltage before transporting the electricity into the National Grid. Use specific equations in your answer. (4 marks)
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- (ii) Calculate the output voltage of the transformer if the turbine produces 690 V and the ratio of turns is 100 in the primary coil to 2500 in the secondary coil. (2 marks)

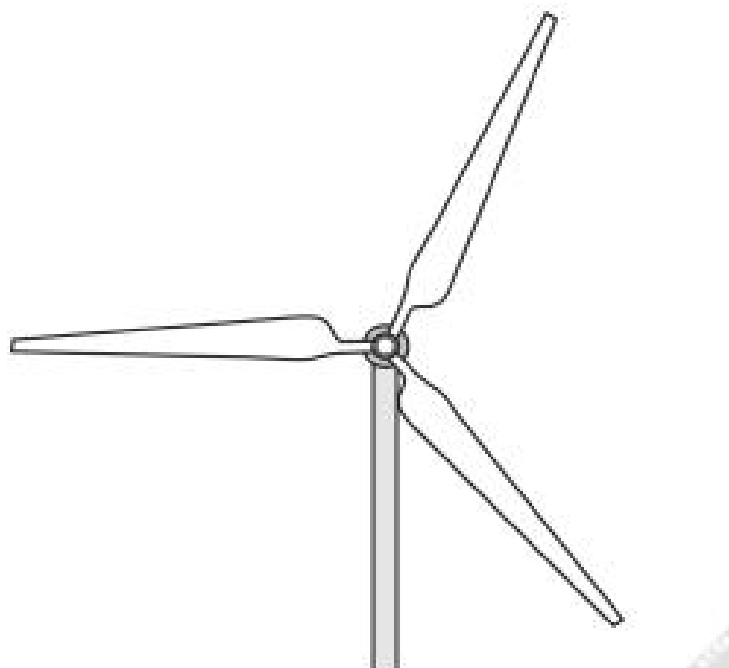
- (b) With specific reference to the text, explain why the pitch of the rotor blades is changed by the operators of the turbine. (4 marks)

- (c) If the 60 m long blades on an average-sized turbine are rotating at 0.20 Hz, estimate the speed of the centre of mass of one of the blades. (4 marks)

_____ m s^{-1}

Consider the three-blade turbine in the diagram to be rotating clockwise. The blade on the left hand side is parallel to the ground. The blades are identical in size and mass.

- (d) (i) Draw the weight forces acting on the blades. (2 marks)



- (ii) Show mathematically that the turbine is balanced in this position. (4 marks)