# PROPELLER

Module 17A

# Syllabus

**17.1 Fundamentals**

- Blade element theory;
- High/low blade angle, reverse angle, angle of attack, rotational speed;
- Propeller slip;
- Aerodynamic, centrifugal, and thrust forces;
- Torque;
- Relative airflow on blade angle of attack;
- Vibration and resonance.

**17.2 Propeller Construction**

- Construction methods and materials used in wooden, composite and metal propellers;
- Blade station, blade face, blade shank, blade back and hub assembly;
- Fixed pitch, controllable pitch, constant speeding propeller;
- Propeller/spinner installation.

**17.3 Propeller Pitch Control**

- Speed control and pitch change methods, mechanical and electrical/electronic;
- Feathering and reverse pitch;
- Overspeed protection.

# Syllabus

**17.4 Propeller Synchronising**

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**17.5 Propeller Ice Protection**

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**17.6 Propeller Maintenance**

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- Blade tracking;
- Assessment of blade damage, erosion, corrosion, impact damage, delamination;
- Propeller treatment/repair schemes;
- Propeller engine running.

**17.7 Propeller Storage and Preservation**

- Propeller preservation and depreservation.

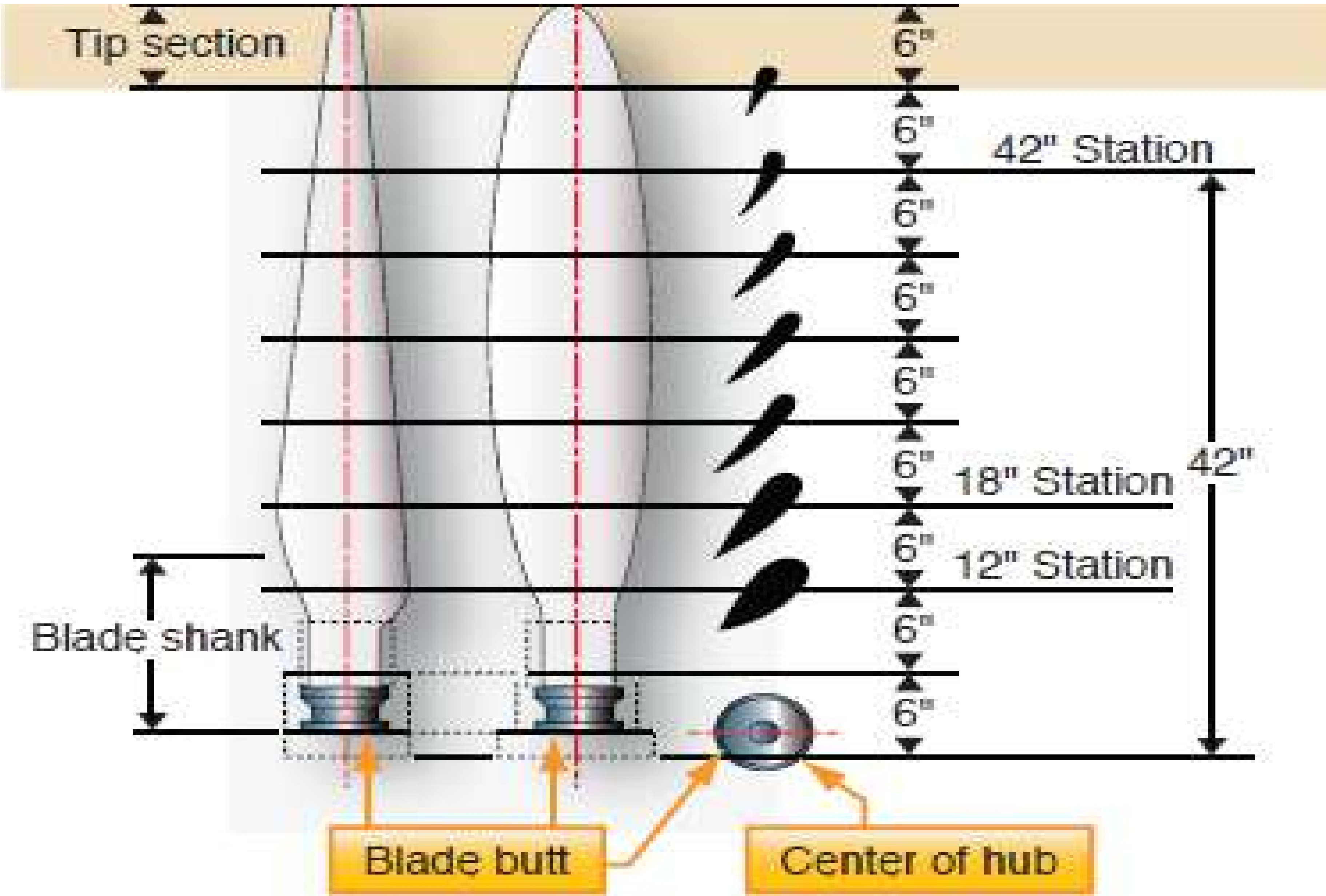
# Aircraft Propeller

- The aircraft propeller consists of two or more blades and a central hub to which the blades are attached.
- Each blade of an aircraft propeller is essentially a rotating wing.
- As a result of their construction, the propeller blades produce forces that create thrust to pull or push the airplane through the air.
- The power needed to rotate the propeller blades is furnished by the engine.
- The propeller is mounted on a shaft that may be an extension of the crankshaft on low-horsepower engines.
- On high horsepower engines, it is mounted on a propeller shaft that is geared to the engine crankshaft.
- In either case, the engine rotates the airfoils of the blades through the air at high speeds, and the propeller transforms the rotary power of the engine into thrust.

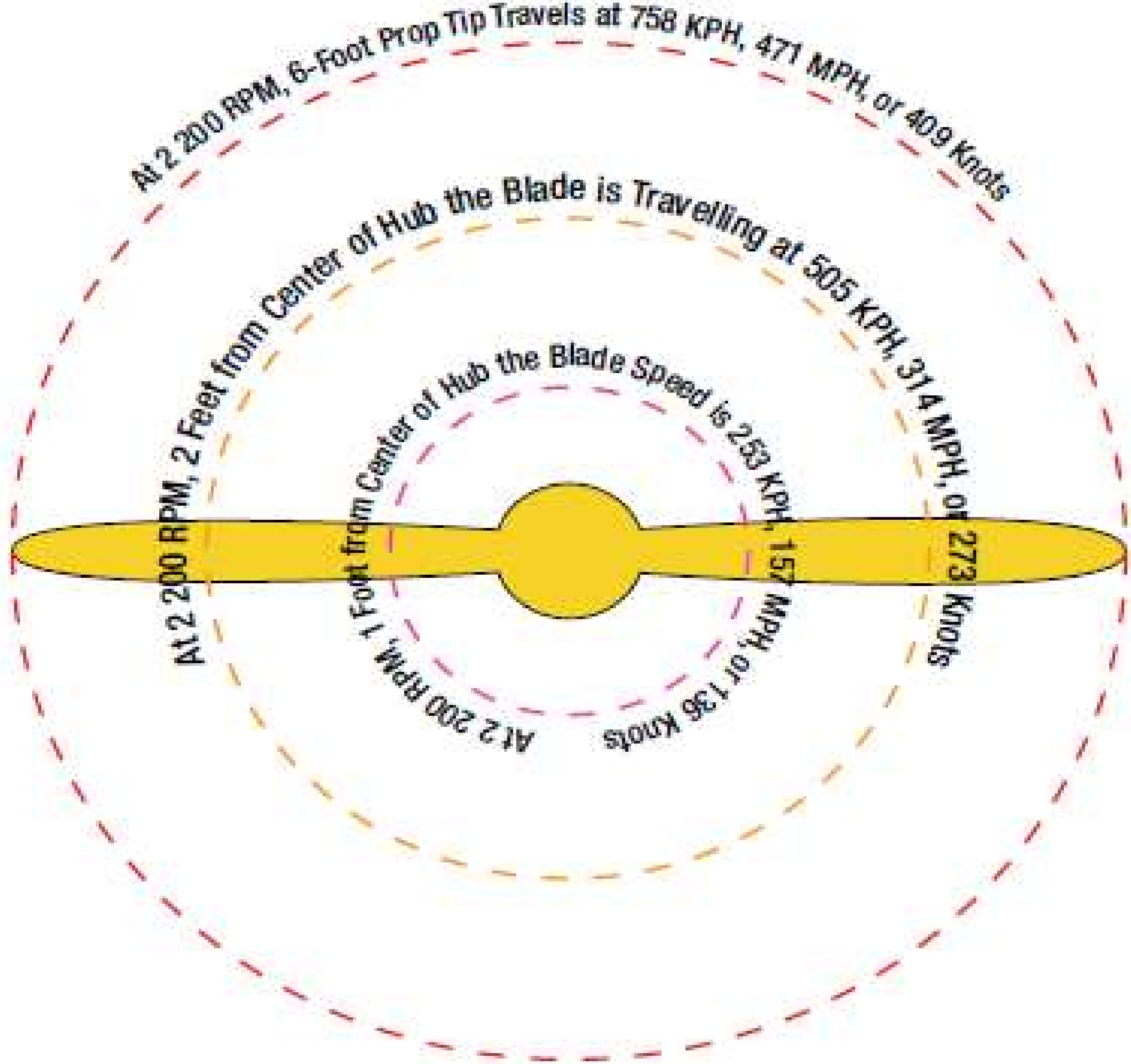

Parts of a Propeller.

# Blade element theory

- ***"A propeller blade can be considered as being composed of an infinite number of thin blade elements, each of which is a miniature airfoil section whose chord is the width of the propeller blade at that section."***
- The typical propeller blade can be described as a twisted airfoil of irregular planform.
- The propeller blade is divided into small segments so that the performance of each segment may be critically analyzed.
- By combining the performance of the segments, designers are able to closely predict the performance of the propeller.
- For purposes of analysis, a blade can be divided into segments that are located by station numbers in inches from the center of the blade hub.
- **The angle of the blade near the hub is higher than the angle at the tip.**
- The reason the propeller blade needs the twist is due to the difference in velocity between the blade at the hub versus the blade at the tip.
- The lower speeds at the hub region benefit from the higher blade angle while the higher speeds at the tip require a lesser blade angle.
- The pitch of the blade changes progressively from the root to the tip to provide the proper interaction with the air along the entire length of the blade.



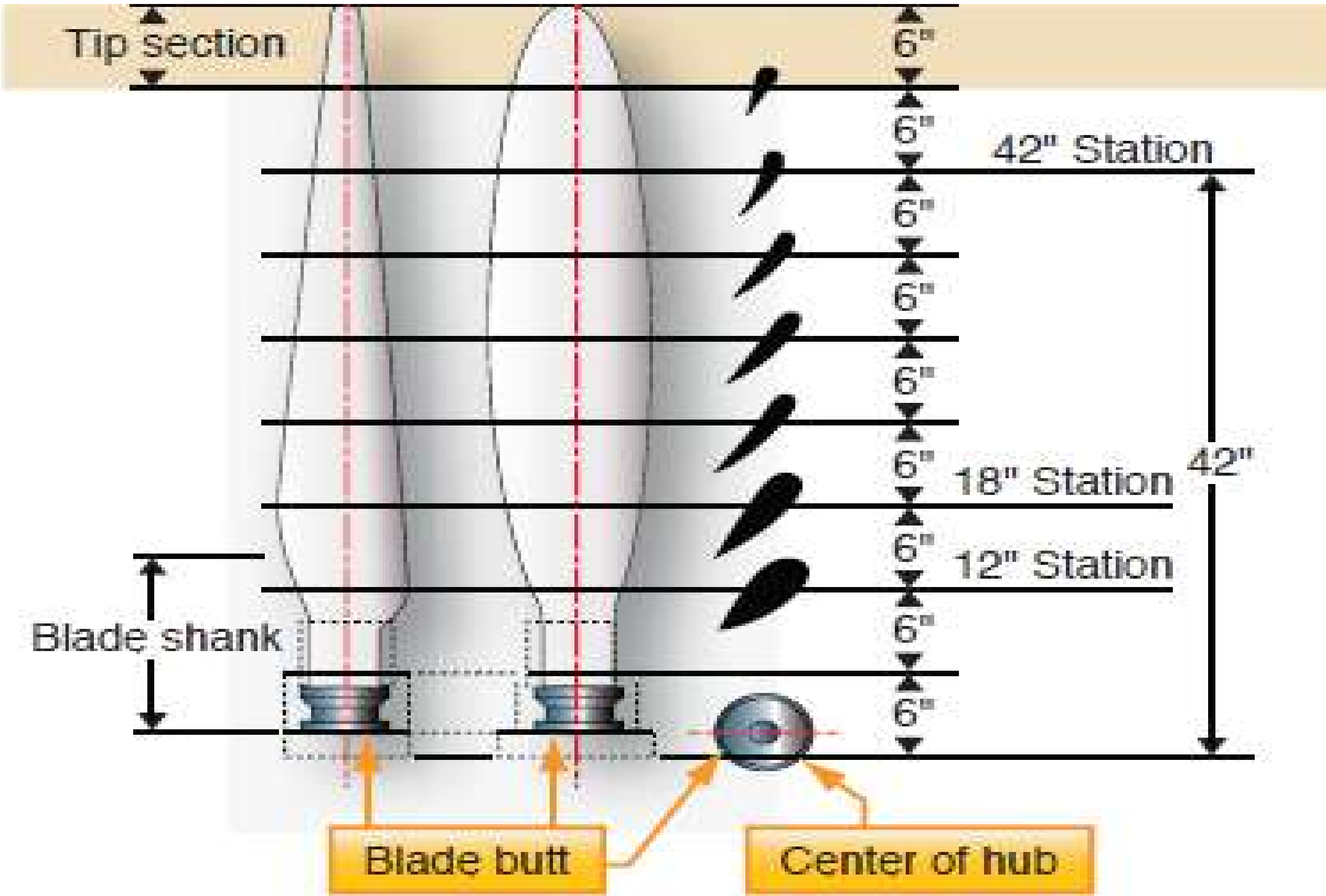

Propeller blade elements demonstrating twist.




Velocities along blade span.

# Terminologies

- The **blade back** is the cambered or curved side of the blade, similar to the upper surface of an aircraft wing.
- The **blade face** is the relatively flat side of the propeller blade similar to the under surface of a wing.
- The **chord line** is an imaginary line drawn through the blade from the leading edge to the trailing edge.
- The **leading edge** is the thick edge of the blade that meets the air as the propeller rotates.
- The **blade shank** is the thick, rounded portion of the propeller blade near the hub and is designed to give strength to the blade.
- The **blade butt**, also called the blade base or root, is the end of the blade that fits in the propeller hub.
- The **blade tip** is that part of the propeller blade farthest from the hub, generally defined as the last 6 inches of the blade.

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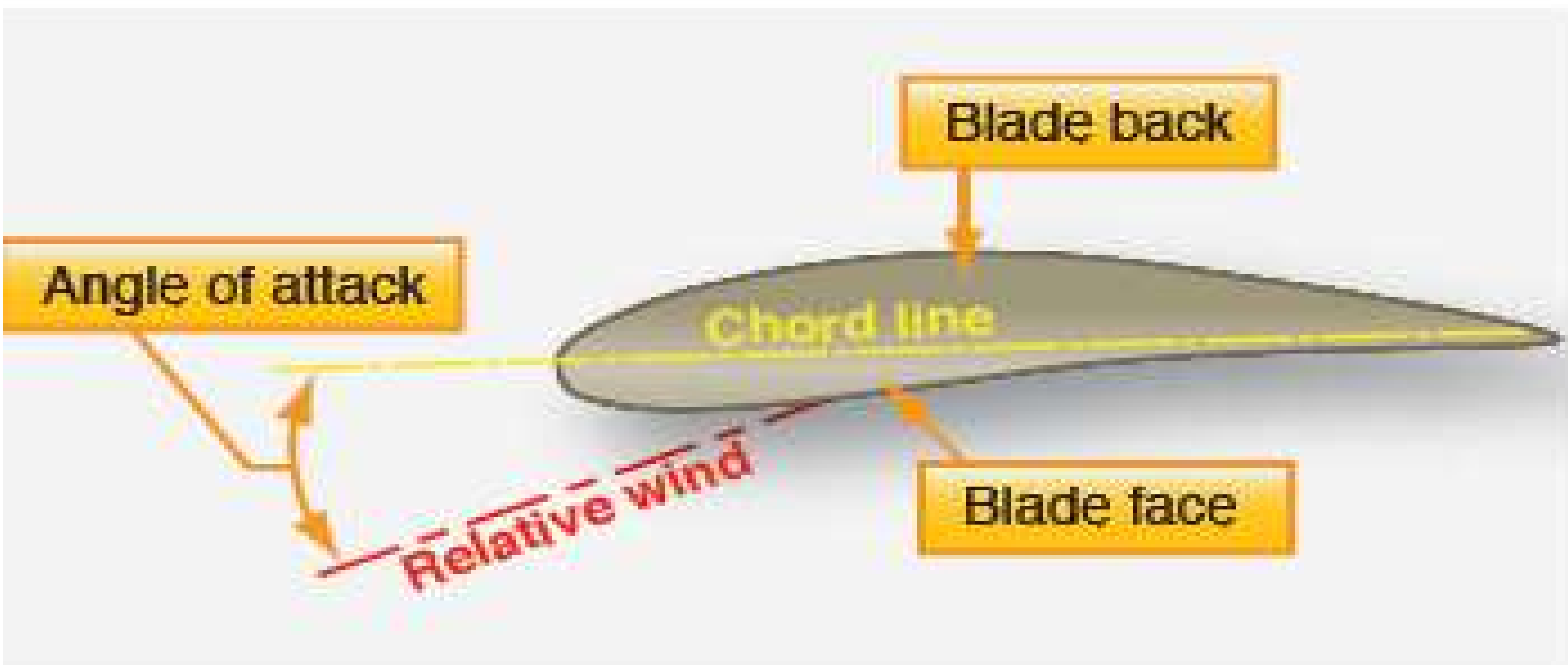
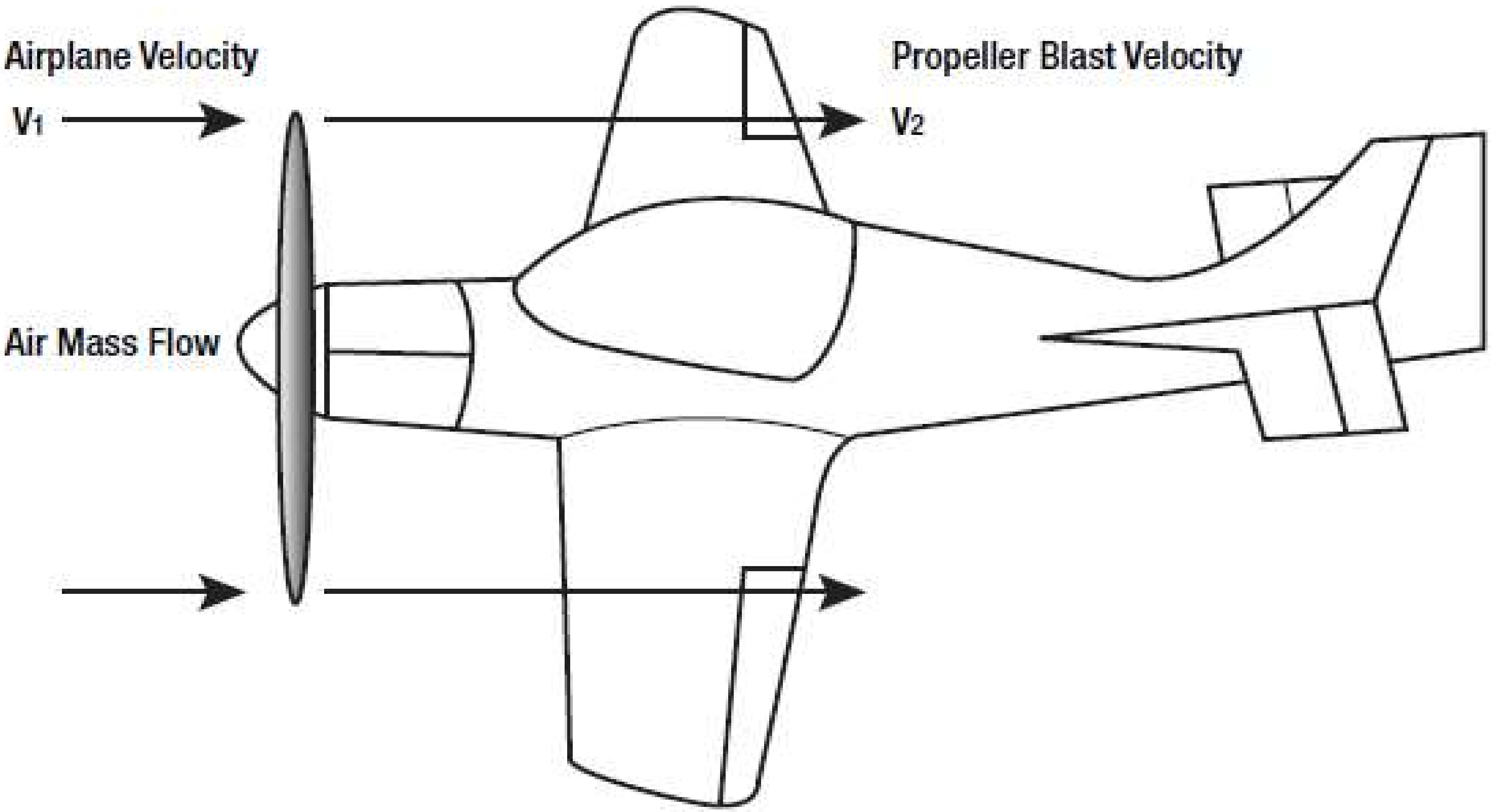



Cross Section of Propeller Airfoil.

*Because most propellers have a flat blade face, the chord line is often drawn along the face of the propeller blade.*

# Thrust Calculation

- The thrust produced by the engine/propeller combination is the result of how much air is pushed and the speed of the moving air mass.
- The resulting action/reaction is in accordance with Newton's Third Law of Motion.
- In comparison to a jet engine, a propeller moves a large mass of air at a relatively slow speed.
- Thrust = Mass flow per second * (V2 – V1)


Airplane Velocity
V1
Propeller Blast Velocity
V2
Air Mass Flow

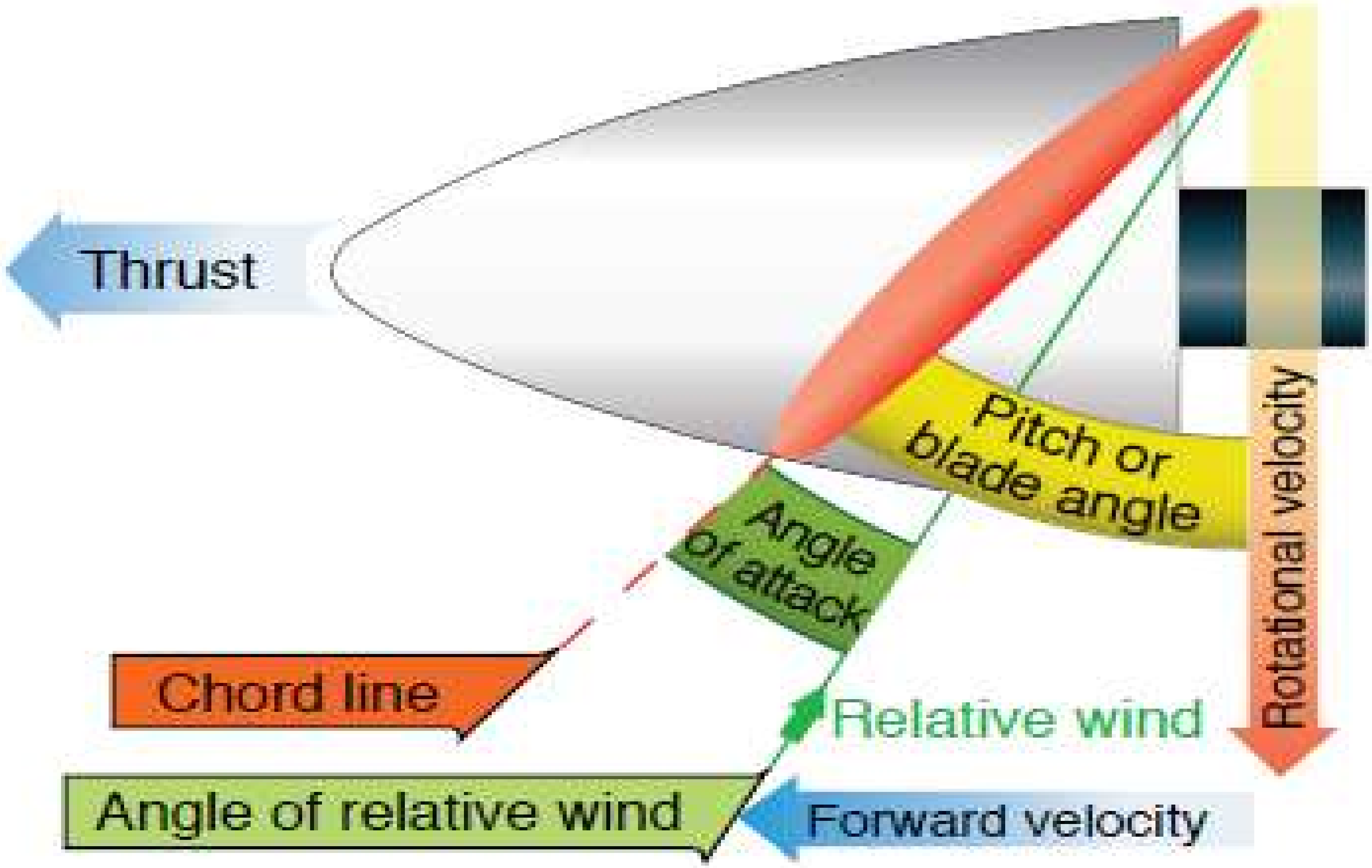
Thrust.

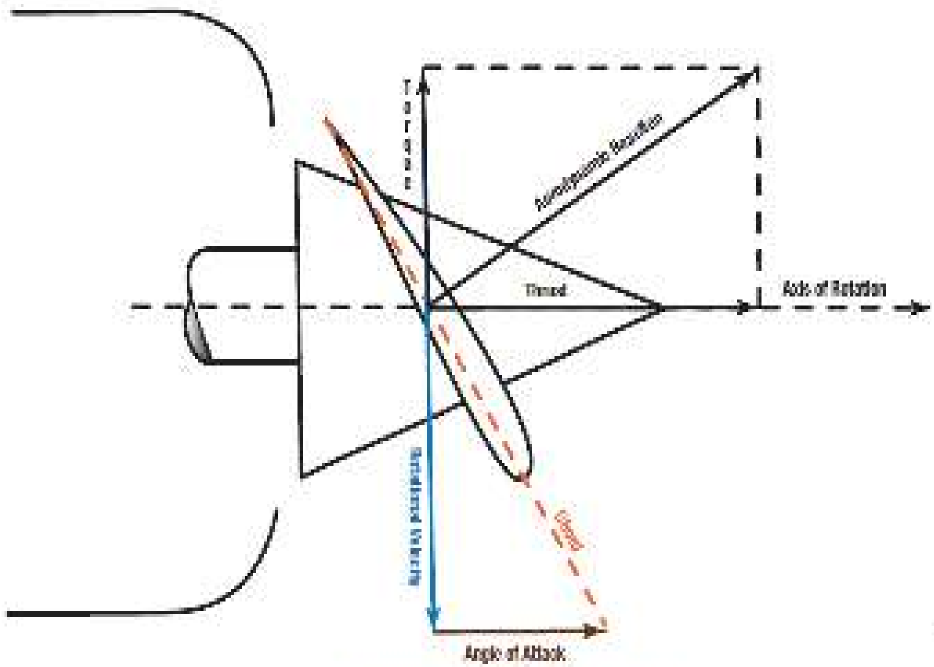
# High/low blade angle, reverse angle, angle of attack, rotational speed

- **Blade Angle**: It is the angle between the face or chord of a blade section and the plane in which the propeller rotates.
- Blade angle and propeller pitch are closely related.
- The blade angle for each segment of a fixed-pitch propeller is the angle formed by the chord line of the blade segment and its plane of rotation.
- *That relationship does not change*.
- *The same is true for controllable-pitch propellers once the blade angle is established.*
- **Angle of Attack**: It is the angle between the face or chord of a blade section and the relative airflow.
- The angle of attack of a fixed-pitch propeller blade varies with forward speed of the aircraft.
- The faster the airspeed of the airplane, the less the angle of attack.

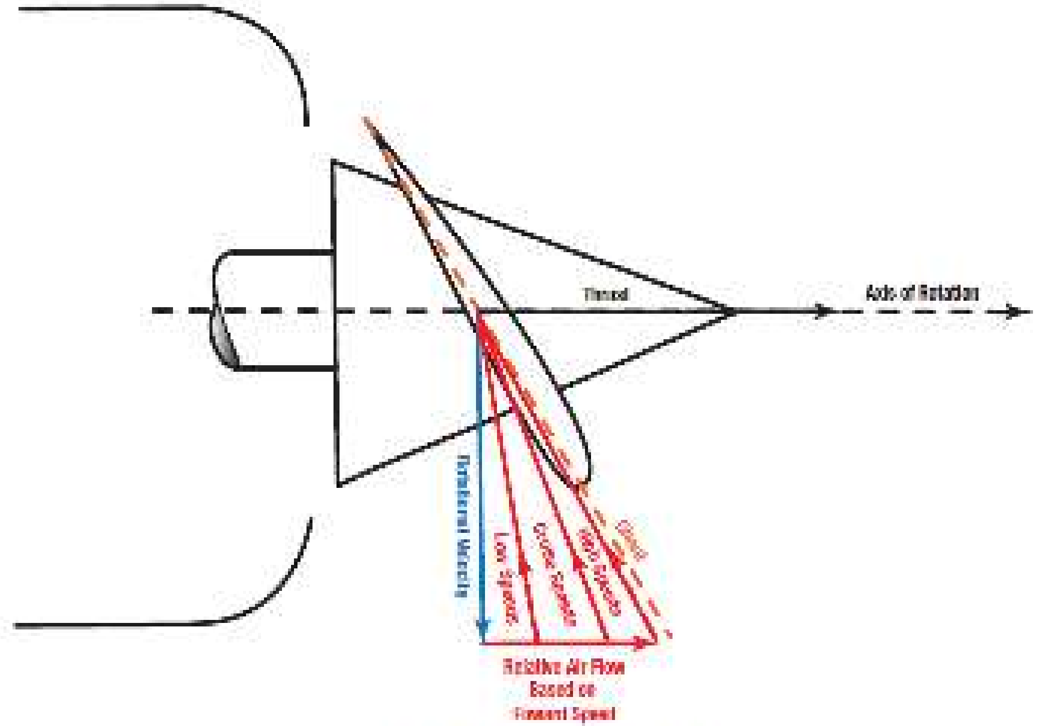
# Relative airflow on blade angle of attack;

- The relative airflow (RAF) encountered by the propeller varies with the speed of the airplane.
- When the aircraft is travelling at a low airspeed, the angle of attack encountered by the propeller blade is high.
- The thrust for a given rpm will be high due to the high angle of attack.
- In terms of efficiency, the slow moving airplane will have poor propeller efficiency.
- At high airspeeds, the angle of attack of the propeller is relatively low.

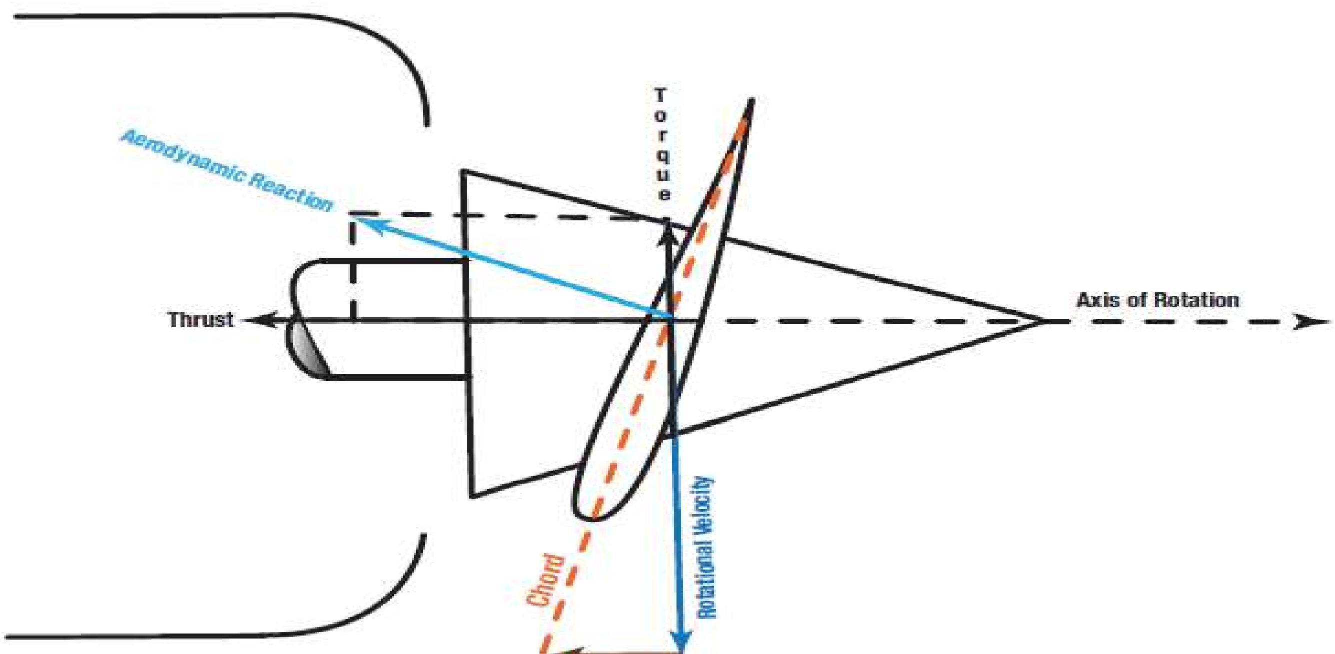

Thrust
Pitch or blade angle
Angle of attack
Chord line
Relative wind
Rotational velocity
Angle of relative wind
Forward velocity




Propeller blade angle with no forward airspeed.




Relative air flow based on forward speed.



# Propeller Evolution

- Successful propellers started as simple two-bladed wood propellers and have advanced to the complex propulsion systems of turboprop aircraft that involve more than just the propeller blades.
- As an outgrowth of operating large, more complex propellers, a variable-pitch, constant-speed feathering and reversing propeller system was developed.
- This system allows the engine rpm to be varied only slightly during different flight conditions and, therefore, increases flying efficiency.
- *A basic constant-speed system consists of a **flyweight-equipped governor** unit that controls the pitch angle of the blades so that the engine speed remains constant*.
- The governor can be regulated by controls in the cockpit so that any desired blade angle setting and engine operating speed can be obtained.
- A low pitch, high rpm setting, for example, can be utilized for takeoff.
- Then, after the aircraft is airborne, a higher pitch and lower rpm setting can be used for cruise operations.
- *Normal propeller movement with the positions of low pitch, high pitch, feather (used to reduce drag if the engine quits), and zero pitch into negative pitch, or reverse pitch.*

# Variable Pitch Propeller Concept

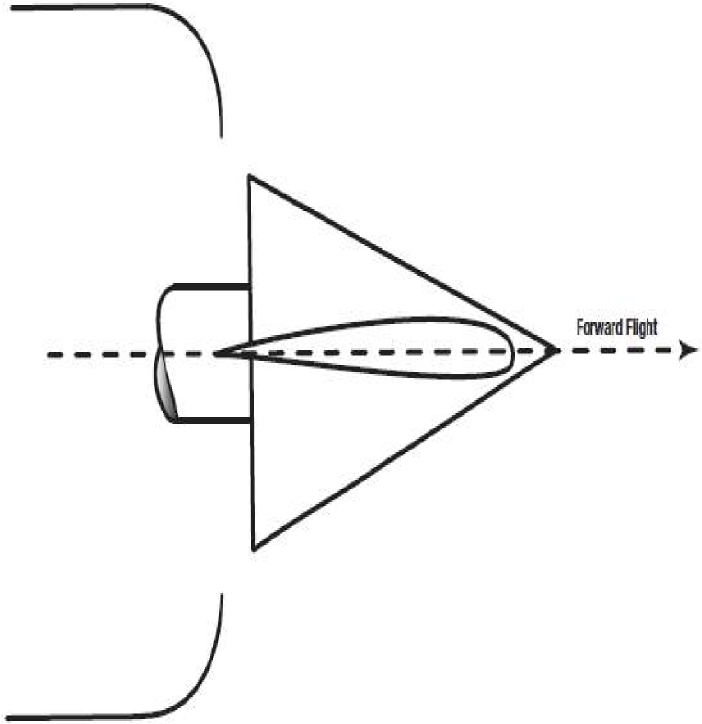
- Where a large number of small airplanes use fixed-pitch propellers, a majority of higher performance aircraft are equipped with propellers that are variable pitch.
- This allows the operator to vary the pitch of the propeller during flight to increase the efficiency of the propeller in order to yield the desired performance in terms of speed and fuel economy.
- These propellers often include a constant-speed mechanism that keeps the engine at the same rpm during cruise flight.
- When the aircraft changes flight attitude (e.g., nose up for altitude gain), the propeller changes pitch to keep the engine at the same rpm.

# Reversing Propeller Concept

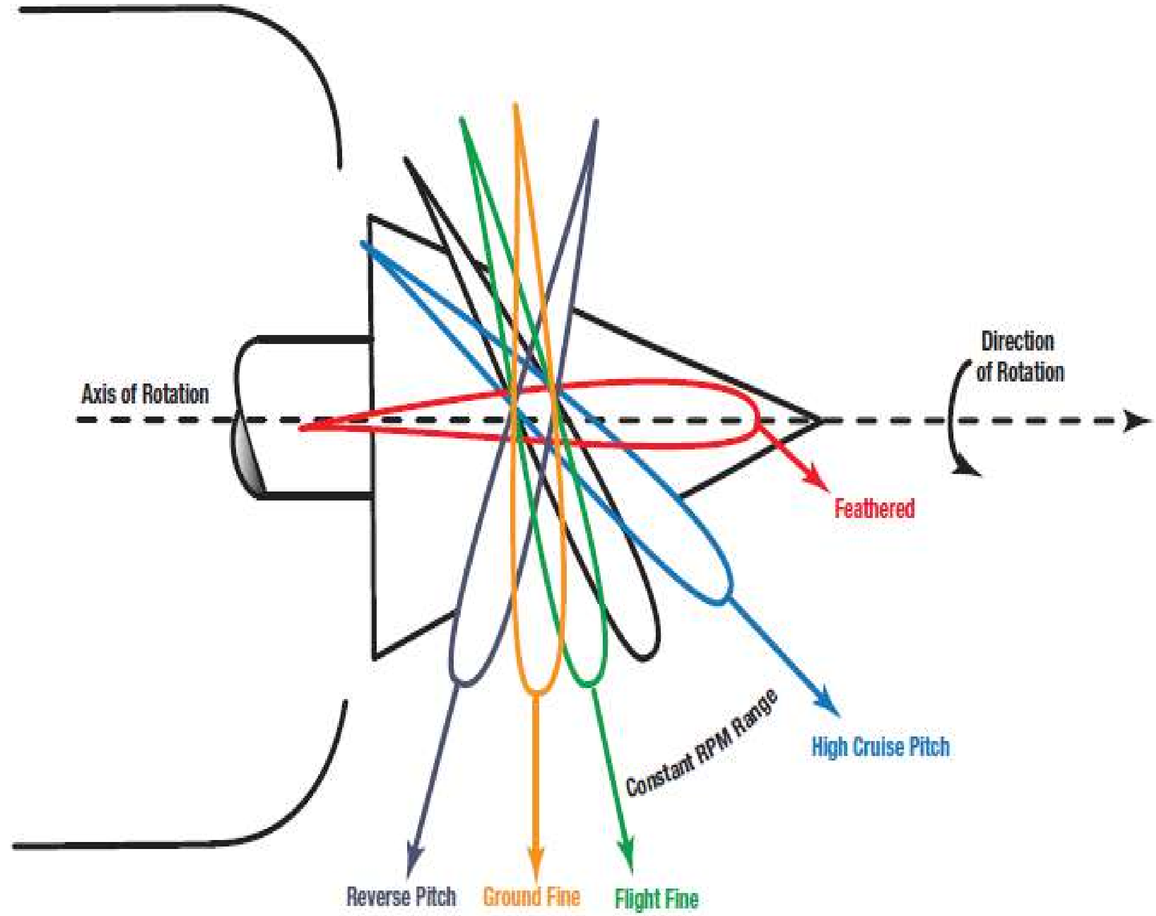
- Some propellers are able to produce reverse thrust.
- This is accomplished by reducing the pitch angle to achieve a negative angle of attack.
- This produces reverse thrust that serves as a means of aerodynamic braking to reduce aircraft speed following landing.
- The ability to reverse the thrust of the propeller is useful for slowing the aircraft after touching down, thereby shortening the length of roll out and allowing the aircraft to operate from a shorter runway than it could otherwise use without reverse thrust while saving a measure of wear on the brake system.
- Some aircraft are able to back-up on the ground using reverse thrust.
- Reverse thrust may prove useful when manoeuvring a seaplane, especially during docking.

# Featherable Propeller Concept

- Multiengine aircraft are normally equipped with propellers that may be feathered.
- This feature is useful for when the aircraft experiences a dead engine or an engine incapable of producing proper thrust during flight.
- Without the ability to feather the propeller, the dead or weak engine would windmill or attempt to windmill.
- Such action generates detrimental drag, making it more difficult for the aircraft to sustain altitude.
- When the propeller is feathered the blade angle is close to 90°.
- Where the propeller tip may not appear to be perpendicular to the plane of rotation, the higher angle of attack of the blade towards the hub is also in play.
- The net result of the aerodynamic action acting on the entire blade is that the propeller does not rotate the engine. The drag produced by the propeller is relatively low as the blades slice through the air during flight.




Feathered propeller blade.




Range of propeller pitch for a variety of flight parameters.

RANGE OF PROPELLER PITCH

Depending on the design of the propeller, the range of pitch may extend from reverse thrust to feathered. Generally speaking, higher performance turboprop aircraft have propellers that include the full range of travel. This provides the aircraft with sufficient propeller capabilities to meet operational requirements.

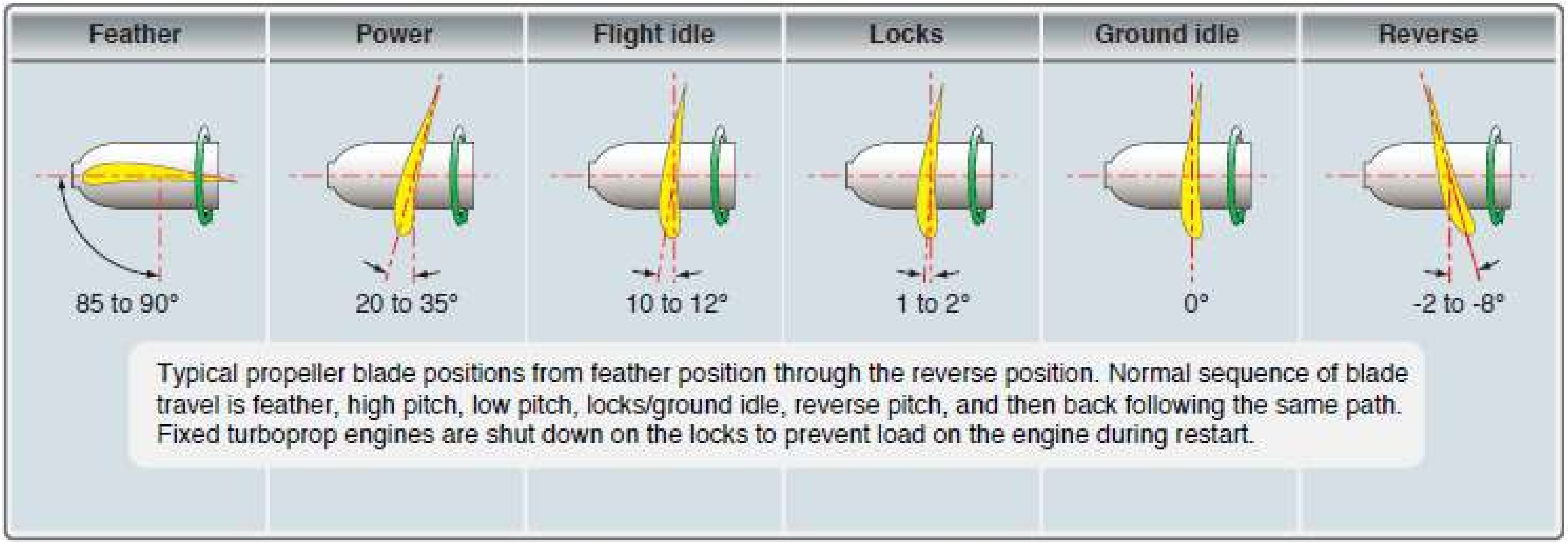



Figure 1-1. Ranges of Propeller Pitch.

# Propeller slip

- An airplane moving through the air creates a drag force opposing its forward motion.
- If an airplane is to fly on a level path at a constant speed, there must be a force applied to it that is equal to the drag but acting forward. This force is called thrust.
- The work done by thrust is equal to the thrust times the distance it moves the airplane.

  Work = Thrust × Distance
- The power expended by thrust is equal to the thrust times the velocity at which it moves the airplane.

  Power = Thrust × Velocity
- If the power is measured in horsepower units, the power expended by the thrust is termed thrust horsepower.
- The engine supplies brake horsepower through a rotating shaft, and the propeller converts it into thrust horsepower.
- In this conversion, some power is wasted. For maximum efficiency, the propeller must be designed to keep this waste as small as possible.
- Since the efficiency of any machine is the ratio of the useful power output to the power input, propeller efficiency is the ratio of thrust horsepower to brake horsepower.
- The usual symbol for propeller efficiency is the Greek letter $\eta$ (eta).
- Propeller efficiency varies from 50 percent to 87 percent, depending on how much the propeller slips.

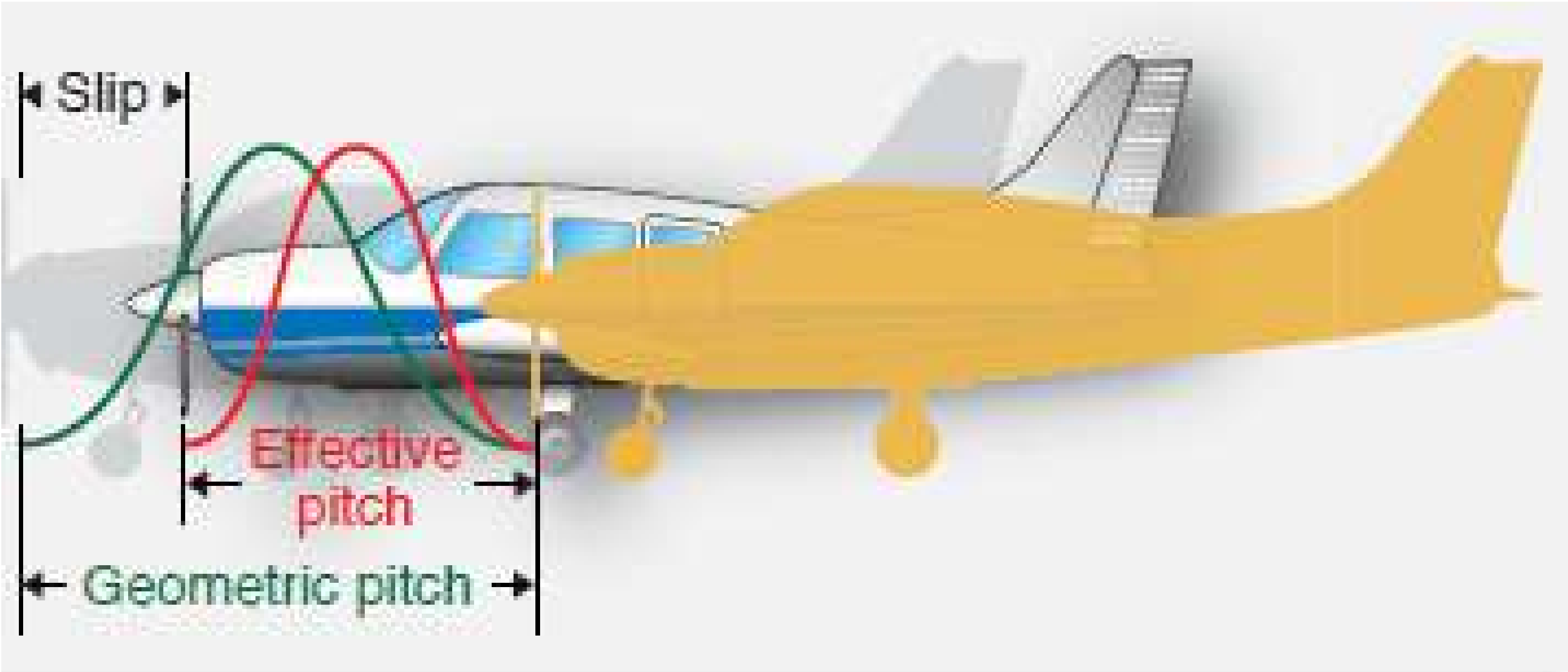
# Propeller slip

- Pitch is not the same as blade angle, but because pitch is largely determined by blade angle, the two terms are often used interchangeably.
- An increase or decrease in one is usually associated with an increase or decrease in the other.
- **Propeller slip** is the difference between the geometric pitch of the propeller and its effective pitch.
- ***Geometric pitch*** *is the distance a propeller should advance in one revolution with no slippage.*
- **Effective pitch** is the distance it actually advances.
- Thus, geometric or theoretical pitch is based on no slippage. Actual, or effective, pitch recognizes propeller slippage in the air. The relationship can be shown as:

  **Slip = Geometric pitch – Effective pitch**
- Geometric pitch is usually expressed in pitch inches and calculated by using the following formula:

  GP = 2 × π R × tangent of blade angle at 75 percent station

  (R = Radius at the 75 percent blade station and π = 3.14)




Effective Pitch versus Geometric Pitch.

# Aerodynamic, centrifugal, and thrust forces

**FORCES ACTING ON A PROPELLER**

- The propeller is subjected to numerous forces. The level of force may be extreme, depending on the operation.
- Forces acting on the propeller during flight include:
  (a) centrifugal force,
  (b) torque bending force,
  (c) thrust bending force,
  (d) aerodynamic twisting force, and
  (e) centrifugal twisting force.

- **(a)Centrifugal force** is a physical action that tends to pull the rotating propeller blades out of the hub.
  *This is the most dominant force on the propeller. The centrifugal load exerted by the blades at high rpm is measured in tons. Damage to the propeller near the root or damage to the hub may result in blade separation.*

- **(b)Torque bending force**, in the form of air resistance, tends to bend the propeller blades in the direction opposite than of rotation.
  *The resistance generated by the rotating blades is basically drag. Under varying flight configurations, the pilot has to use the flight controls to compensate for the torque generated by the engine/ propeller combination.*

- **(c) Thrust bending force** is the thrust load that bends propeller blades forward as the aircraft is pulled through the air.
  *The thrust bending force is more prominent at the tip of the propeller blade. The relative thinness of the propeller blade in the tip area allows that section to bend forward in response to the generation of thrust.*

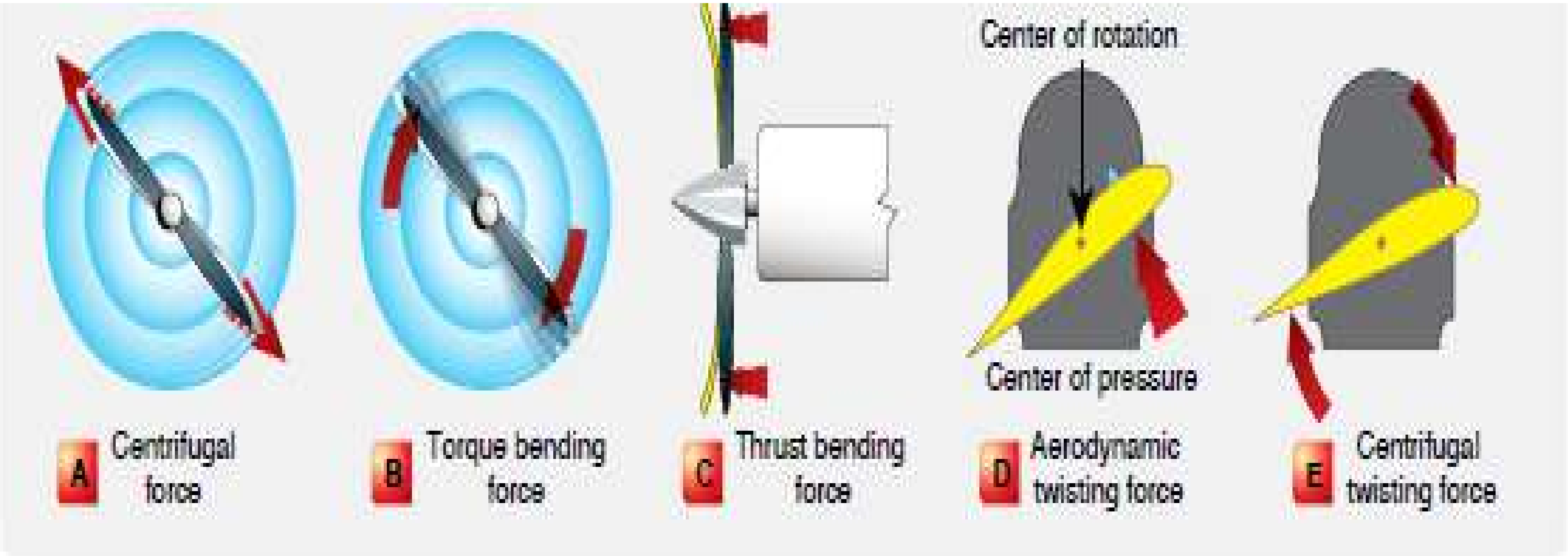
# Aerodynamic, centrifugal, and thrust forces

- **(d)Aerodynamic twisting force (ATF), also known as aerodynamic twisting moment (ATM),** tends to rotate the propeller blades to a high blade angle.

  *This force is generated as the propeller produces thrust. Because the axis of rotation of the propeller blade in terms of pitch angle is approximately the midpoint along the chord, the center of pressure generated by the aerodynamic action of the blade interacting with the air imparts a force nearer the leading edge of the blade. The result is that the blade tries to move in the direction of higher pitch. ATM may be incorporated to increase the pitch of the blades during flight.*
- **(e)Centrifugal twisting force (CTF), also known as centrifugal twisting moment (CTM) ,** is generated as the propeller rotates. Because the axis of blade pitch rotation is basically the midpoint of the chord, the mass of the propeller blade on each side of the axis of rotation works to reduce propeller pitch due to the centrifugal force generated. As with the other forces acting on the propeller blades, the higher the rpm, the greater the CTM. When compared to the aerodynamic twisting moment, the centrifugal twisting moment is more powerful and tends to force the propeller blades toward a low blade angle.

# Aerodynamic, centrifugal, and thrust forces

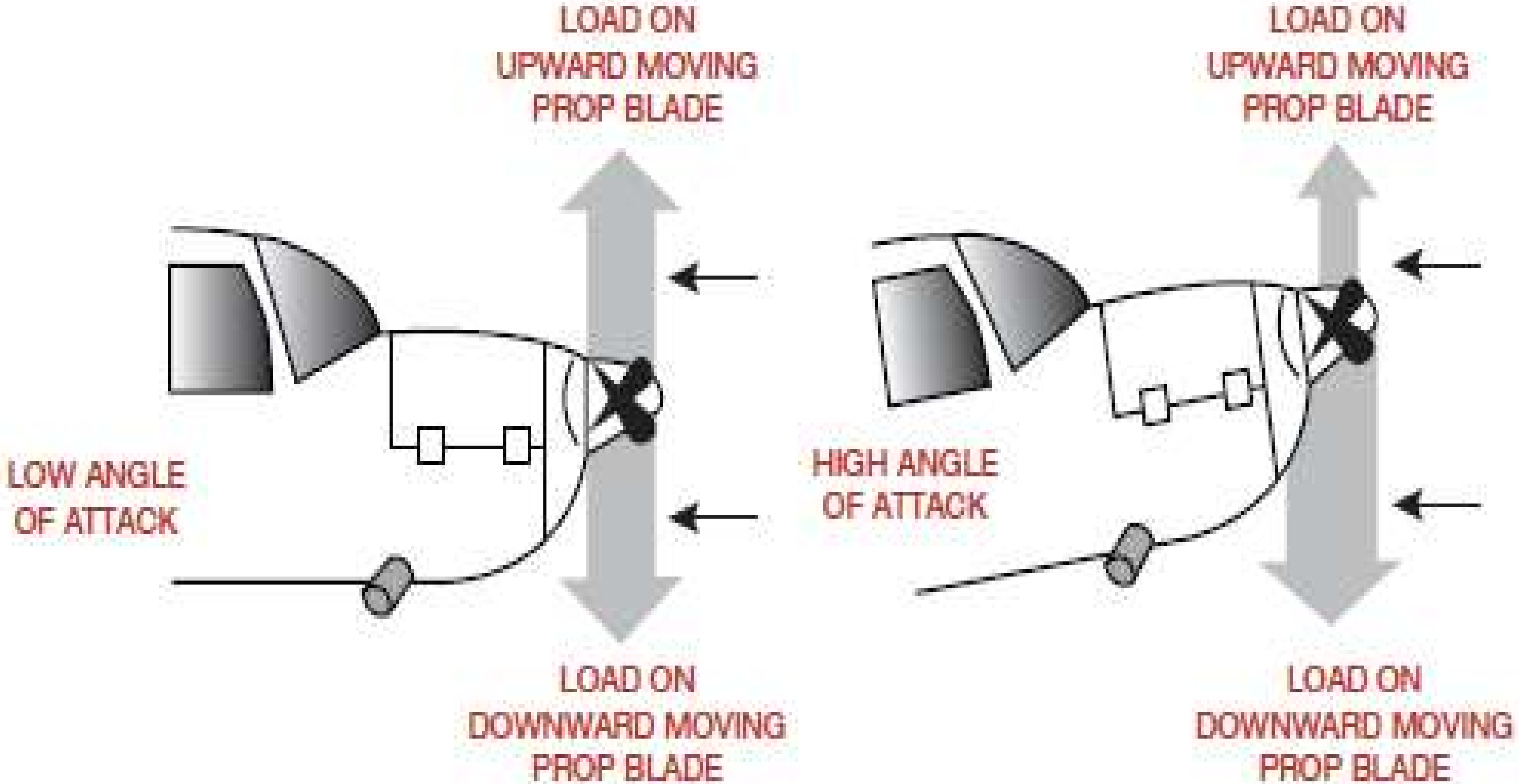
- Two of these forces acting on the propeller's blades are used to move the blades on a controllable pitch propeller.
- Centrifugal twisting moment (CTM) is sometimes used to move the blades to the low pitch position, while aerodynamic twisting moment (ATM) is used to move the blades into high pitch.
- These forces can be the primary or secondary forces that move the blades to the new pitch position.
- In terms of construction, a propeller must be capable of withstanding severe stresses, which are greater near the hub, caused by centrifugal force and thrust. The stresses increase in proportion to the rpm.
- The blade face is also subjected to tension from the centrifugal force and additional tension from the thrust bending force. For these reasons, nicks or scratches on the blade may cause very serious consequences. These could lead to cracks and failure of the blade.
- A propeller must also be rigid enough to prevent fluttering, a type of vibration in which the ends of the blade twist back and forth at high frequency around an axis perpendicular to the engine crankshaft.
- Fluttering is accompanied by a distinctive noise, often mistaken for exhaust noise. The constant vibration and resonance tends to weaken the blade and eventually causes failure.




. Forces acting on a propeller.

# P-FACTOR

- When an airplane is flying in a level attitude, the thrust developed by the propeller is fairly uniform between the descending blade and the ascending blade.
- Raising the nose of the aircraft produces asymmetrical thrust between the ascending and descending propeller blades. This is often referred to as “P-Factor.”
- P-Factor is generated during climbs because the descending blade has a greater angle of attack than the ascending blade.
- The difference in thrust between the right and left regions of the propeller disc generates a yawing moment.
- For right-hand rotating propellers, a left yawing moment is formed.
- Pilots compensate for P-Factor by applying the necessary rudder input.



LOAD ON
UPWARD MOVING
PROP BLADE
LOW ANGLE
OF ATTACK
LOAD ON
DOWNWARD MOVING
PROP BLADE
LOAD ON
UPWARD MOVING
PROP BLADE
HIGH ANGLE
OF ATTACK
LOAD ON
DOWNWARD MOVING
PROP BLADE


P-Factor.

# SLIPSTREAM EFFECT

- Another occurrence generated by the flowing air mass of the propeller is the slipstream effect.
- As the air acted upon by the propeller flows aft, it flows around the surface of the aircraft at an accelerated speed when compared to air flowing over the surface outside the propeller disc.
- Control surfaces within the path of the slipstream benefit from the accelerated flow and become more effective.
- The slipstream generated by the propeller also has a whirling action as it flows aft.
- This rotating air mass on single-engine aircraft, or aircraft with a propeller in the nose, experience a yawing action due to the striking of the air against the vertical fin.
- For right-hand rotating propellers, the aircraft develops a yawing moment to the left.
- Aircraft designers often compensate for the slipstream effect by offsetting the vertical fin, incorporating a corrective measure with the rudder, or applying a slight offset of the thrust line of the engine by designing the engine mount with a corrective installation angle.
- Such corrective measures may also soften the effect of P-Factor.

# Torque;

- Torque is a natural resistance to a rotating mass.
- As the propeller revolves in one direction, torque works to rotate the airplane in the opposite direction. This follows Newton's Third Law of Motion that states, for every action there is an equal and opposite reaction.
- On a right-hand rotating propeller, torque works to drop the left wing. The greater the power/rpm, the greater the torque effect.
- High power operations, in combination with low airspeeds, increase the torque effect.
- Often aerobatic pilots will demonstrate "torque rolls" by pointing the nose of the airplane vertically up with full power. As the airspeed approaches zero, the aircraft will begin to revolve in the opposite direction of the rotating propeller.
- Pilots experience the effect of torque, P-Factor, and slipstream effect when they perform power-on stalls.
- During the manoeuvre, the throttle is placed at full power and the nose of the aircraft is lifted until the aircraft stalls. When the stall is entered, the pilot will implement corrective control inputs to compensate for the torque and other effects while recovering from the stall.
- If the throttle is reduced to idle, or a low-power setting during the stall, the effects of torque, P-Factor, and slipstream action are greatly reduced.

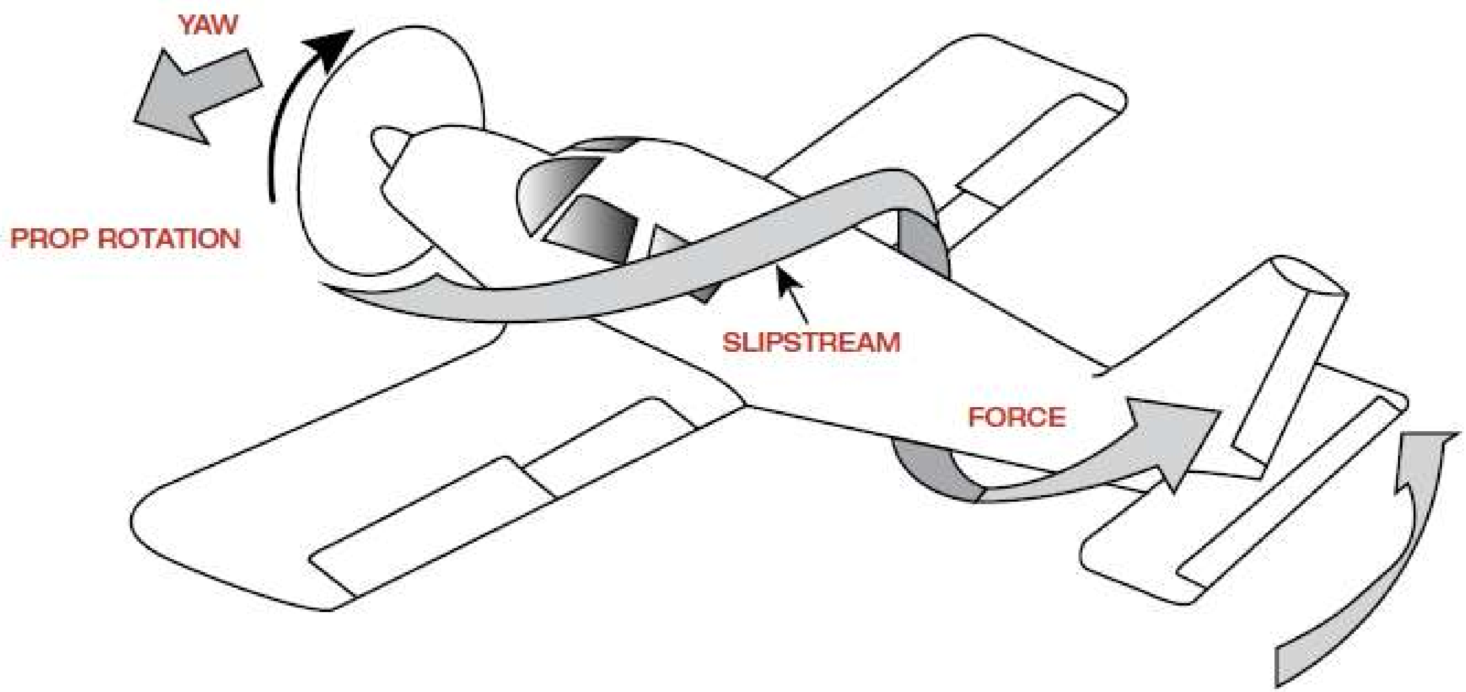



Figure 1-16. Slipstream Effect.

# GYROSCOPIC PRECESSION

- The rotating propeller is, in effect, a gyroscope. The rotating mass will generate a measure of gyroscopic rigidity and precession. The latter produces a small, but noticeable, reaction during operation.
- Gyroscopic precession is the response of a gyroscope to generate an action 90° from the point of input in the direction of rotation.
- To illustrate, when an aircraft equipped with a right-hand rotating propeller is yawed to the left, gyroscopic precession will work to lift the nose.
- During takeoff roll of an aircraft equipped with a tail wheel, when the pilot raises the tail, the aircraft develops a yawing action to the left.
- In general, the effects of gyroscopic precession are minor. The pilot is able to make inputs into the flight control system to counteract gyroscopic precession.

# Vibration and resonance

- During operation, the propeller is subjected to vibrations. The mechanical and aerodynamic forces acting on the propeller generate vibrations.
- Such vibrations are harmful when they result in extreme blade flexing.
- High levels of flexing will work harden the metallic blade and may cause sections of the blade to break off.
- The area near the propeller tip is of great concern as the thinness of the metal in combination with the high air speeds encountered during high rpm operations make this portion of the propeller blade vulnerable.
- Manufacturers of propellers must design the propeller to withstand the operational vibration for the particular airframe/engine/ propeller installation.
- Some aircraft have red arcs on the tachometer to indicate operational rpms that are harmful. Pilots are allowed to accelerate and decelerate through and beyond the red arc, or critical rmp range, but must avoid continuous operations within the range of the red arc.
- Metal propeller blades may possess multiple resonant frequencies, usually two, that result in considerable flexing of the blade. The hinge point where the flexing concentrates is referred to as a **node point or nodal point**.
- If the blade receives physical damage in this exact location or a repair is improperly performed at the node point, there is a likelihood that the blade will fail at that location over the course of operations.
- Between the mechanical impulses applied to the propeller and the aerodynamic forces absorbed by the propeller, metal propeller blades, usually aluminum, must be designed to withstand the natural vibrations generated during operation.
- A proven approach to minimizing damage that may occur to the propeller from resonance is to generate forces between the airframe, engine, and propeller that do not closely match the natural resonant frequencies of the propeller.


Red arc from 1 800 to 2 000 rpm.

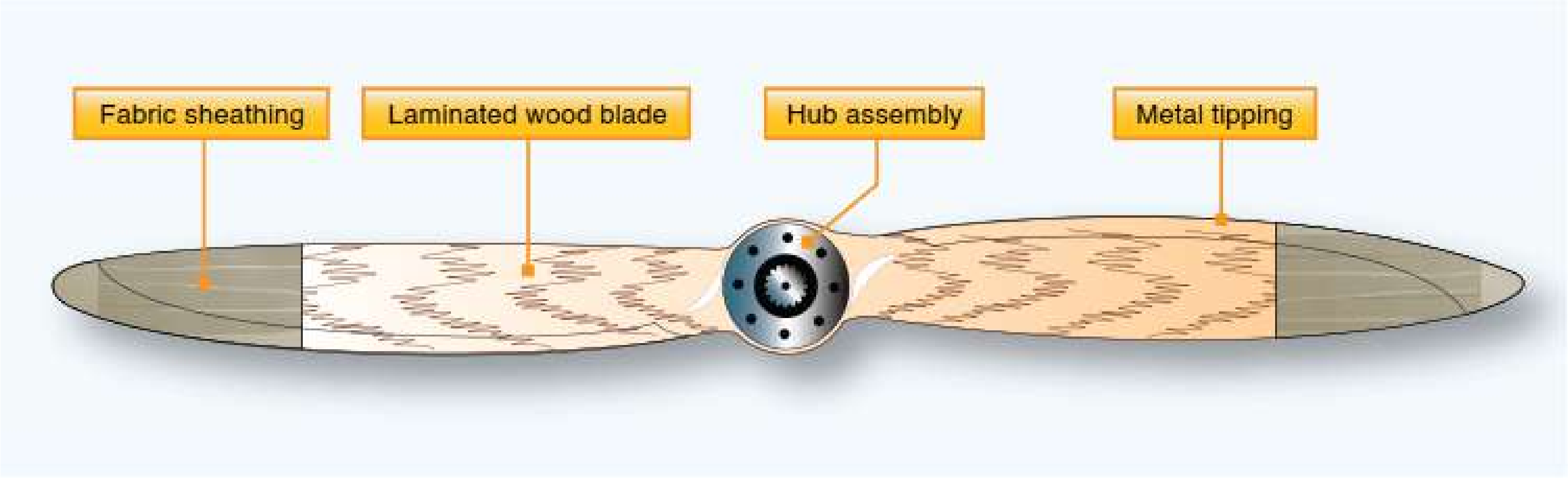
# 17.2 Propeller Construction

## Construction methods and materials used in wooden, composite and metal propellers;

- An increasing number of light aircraft are designed for operation with governor regulated, constant-speed propellers.
- A majority of small, single engine aircraft use fixed-pitch metal propellers.
- Some light sport aircraft (LSA) use multi blade fixed-pitch composite propellers.
- Medium size turbo prop aircraft will often be equipped controllable propellers with pitch reversing systems.
- Larger transport and cargo turbo prop aircraft use propeller systems with dual or double acting governors and differential oil pressure to change pitch.

# Fixed Pitch wooden Propeller

- Although many of the wood propellers were used on older airplanes, some are still in use.
- Early aviation pioneers carved propellers from laminated wooden blanks using hand tools.
- The construction of a fixed-pitch, wooden propeller is such that its blade pitch cannot be changed after manufacture.
- The choice of the blade angle is decided by the normal use of the propeller on an aircraft during level flight when the engine performs in an efficient manner.
- The impossibility of changing the blade pitch on the fixed-pitch propeller restricts its use to small aircraft with low horsepower engines in which maximum engine efficiency during all flight conditions is of lesser significance than in larger aircraft.
- The wooden, fixed-pitch propeller is well suited for small aircraft because of its lightweight, rigidity, economy of production, simplicity of construction, and ease of replacement.
- Because many small aircraft have a variety of approved propellers for installation, aircraft owners or operators have the option of selecting the appropriate propeller for their operation.




Wooden propeller.

# Construction methods and materials used in wooden, composite and metal propellers;

- The two common options are a "climb prop" or "cruise prop."
- **Climb propellers** generally have a lower pitch or shorter diameter that allows the engine to attain higher rpms.
- **Cruise propellers** are built with higher pitch angles and longer diameters and are well suited for cruise operations.
- A wooden propeller is not constructed from a solid block of wood, but is built up of a number of separate layers or laminates of carefully selected and well seasoned hardwoods.
- Many woods, such as mahogany, cherry, black walnut and oak, are used to some extent, but **birch** is the most widely used.
- **Five to nine** separate layers are typically used, each about **¾ inch (2 cm) thick**. Generally, the growth rings of the laminates are alternated in terms of direction to minimize warping.
- The wood laminates are glued together using a waterproof, resinous glue and allowed to set. The blank is then roughed out to the approximate shape and size of the finished product. The roughed out propeller is then allowed to dry for approximately one week to permit the moisture content of the layers to become equalized.
- This additional period of seasoning prevents warping and cracking that might occur if it was immediately carved from a blank. Following this period, the propeller is

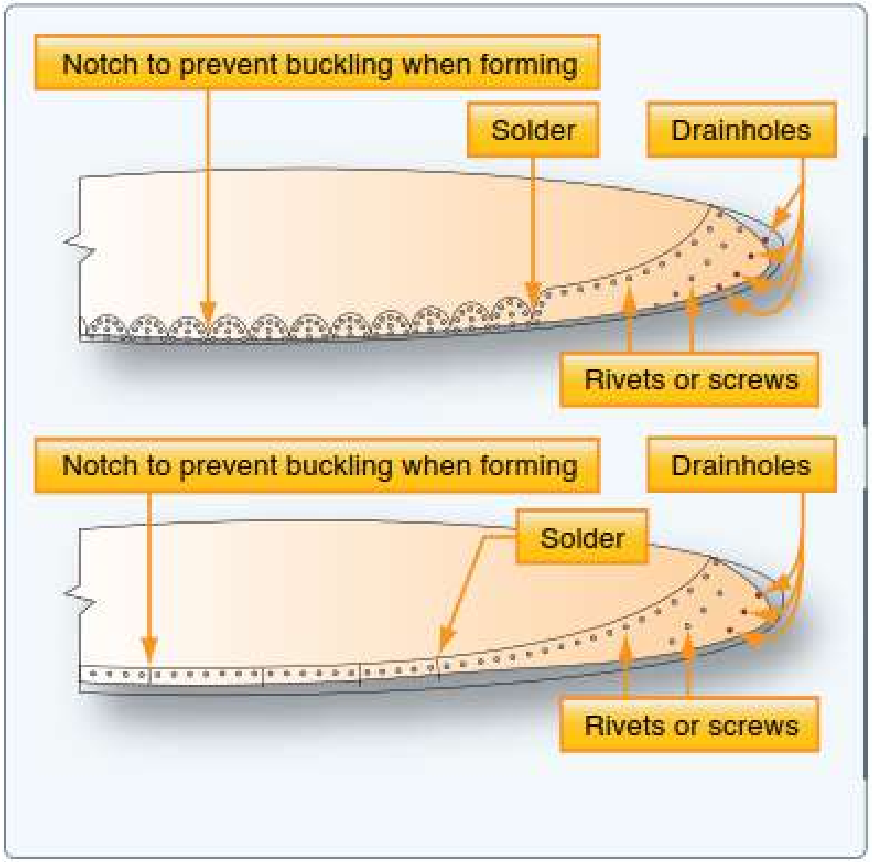
Propeller data. This propeller has a 72-inch diameter with a 44-inch pitch. It could serve as a climb propeller on some airplanes and a cruise propeller on others. Note the laminates.


Wooden propeller showing spinner, hub, laminates, metal tipping, fabric covering, and drain holes.

# Construction methods and materials used in wooden, composite and metal propellers;

- Templates and bench protractors are used to assure the proper contour and blade angle at all stations.

- After the propeller blades are finished, a fabric covering is cemented to the outer 12 to 15 inches (30 to 38 cm) of each finished blade.
- A metal or composite tipping is fastened to the leading edge and tip of each blade to protect the propeller from damage caused by flying particles in the air during landing, taxiing, or takeoff.
- The tipping also serves as an erosion strip to protect the leading edge of the propeller.
- Metal tipping may be of terneplate, monel metal, or brass. Stainless steel has been used to some extent. The metal tipping is secured to the leading edge of the blade by countersunk wood screws and rivets.
- The heads of the screws are soldered to the tipping to prevent loosening, and the solder is filed to make a smooth surface.
- Since moisture condenses on the tipping between the metal and the wood, the tipping is provided with small holes near the blade tip to allow this moisture to drain away or be thrown out by centrifugal force.
- It is important that these drain holes be kept open at all times.
- When the aircraft is inactive for an extended period, the engine is positioned so that the wooden propeller remains in a horizontal position to maintain even water content between the blades.
- If the blades are left in a vertical position for a protracted period, water in the wood will tend to migrate to the lower blade.




Wooden propeller tipping.

Tip on wooden propeller revealing soldered attachment hardware and drain holes.

# Construction methods and materials used in wooden, composite and metal propellers;

- Since wood is subject to swelling, shrinking, and warping because of changes of moisture content, a protective coating is applied to the finished propeller to prevent a rapid change of moisture content.
- The finish most commonly used is a number of coats of water repellent, clear varnish.
- After these processes are completed, the propeller is mounted on a spindle and very carefully balanced.
- Several types of hubs are used to mount wooden propellers on the engine crankshaft.
- The propeller may have a forged steel hub that fits a **splined crankshaft**.
- It may be connected to a **tapered crankshaft** by a tapered, forged steel hub.
- Or it may be bolted to a steel **flange forged on the crankshaft**.
- In any case, several attaching parts are required to mount the propeller on the shaft properly.

- Hubs fitting a tapered shaft are usually held in place by a retaining nut that screws onto the end of the crankshaft. A lengthy metal key is used to align the propeller hub with the crankshaft.
- Proper positioning of the propeller on the crankshaft in terms of clock angle is needed when the engine is started by hand cranking or propping.
- A snap ring is used in many hubs. The snap ring retains the crankshaft nut when the propeller is removed from the engine. The snap ring also serves as a pulling surface when breaking the hub free from the tapered crankshaft using the crankshaft nut. A loud cracking sound is emitted when the hub is broken free from the tapered crankshaft.

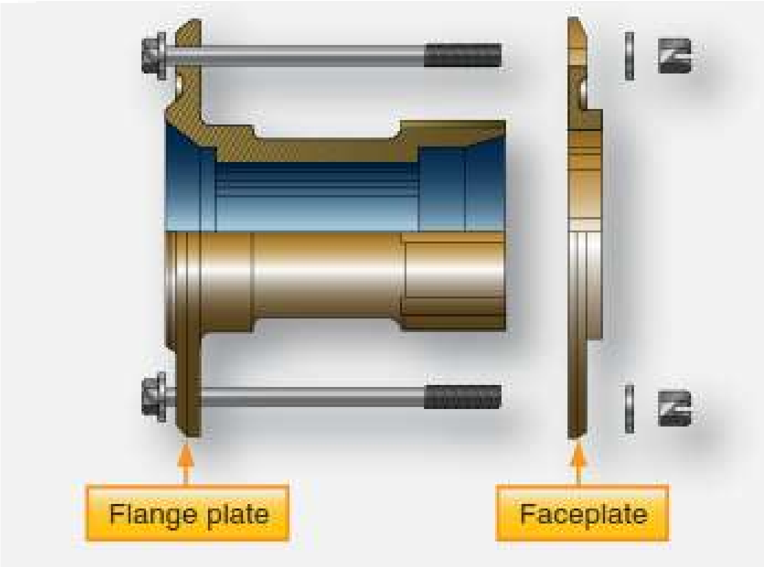
- On splined shaft installations, front and rear cones may be used to accurately center the propeller on the crankshaft or propeller shaft and seat the propeller.
- The rear cone is a one piece bronze design that fits around the shaft and against the thrust nut (or spacer) and seats in the rear cone recess of the hub.
- The front cone is a two piece, split type steel cone that has a groove around its inner circumference so that it can be fitted over a flange of the propeller retaining nut.
- Then, the retaining nut is threaded into place and the front cone seats in the front cone hub.
- A snap ring is fitted into a groove in the hub in front of the front cone so that when the retaining nut is unscrewed from the propeller shaft, the front cone acts against the snap ring and pulls the propeller from the shaft.

- One type of hub incorporates a bronze bushing instead of a front cone. When this type of hub is used, it may be necessary to use a puller to start the propeller from the shaft.
- A rear cone spacer is sometimes provided with the splined shaft propeller assembly to prevent the propeller from interfering with the engine cowling. The wide flange on the rear face of some types of hubs eliminates the use of a rear cone spacer.

- One type of hub assembly for the fixed-pitch, wooden propeller is a steel fitting inserted in the propeller to mount it on the propeller shaft. It has two main parts:

the faceplate and the flange plate.

- The faceplate is a steel disk that forms the forward face of the hub. The flange plate is a steel flange with an internal bore splined to receive the propeller shaft.
- The end of the flange plate opposite the flange disk is externally splined to receive the faceplate. The faceplate bore has splines to match these external splines.
- The units used on lower horsepower engines with tapered shafts generally do not have these splines.
- Both faceplate and flange plates have a corresponding series of holes drilled on the disk surface concentric with the hub center.
- The bore of the flange plate has a 15° cone seat on the rear end and a 30° cone seat on the forward end to center the hub accurately on the propeller shaft.




Wooden propeller hub adapter.

# Propeller/spinner installation

**TORQUING WOODEN PROPELLERS**

- Always refer to the current manufacturer's technical data for explicit maintenance instructions.
- The installation of a wooden propeller must adhere to strict torquing procedures.
- The torque placed on a wooden propeller must be enough to apply a compressive force to the hub without crushing the wood.
- Before installing the propeller, or checking the torque, ensure that the magneto switch(es) are in the OFF position and that the aircraft is chocked or tied-down.
- Removing a spark plug from each cylinder will further enhance safety and will make it easier to rotate the engine for torquing purposes and for checking propeller track.
- Always use an accurate torque wrench that fulfills calibration requirements.
- The propeller bolts should be tightened using a star pattern.
- Increase the tightness of the bolts using small incremental increases of torque.
- Keep shifting from one bolt to the next using the star pattern.
- Continue the process until the prescribed torque value is attained.
- If self-locking nuts are used to retain the propeller, add the resistance of the friction of the self-locking mechanism to the published torque value.
- The reason that the technician should use small incremental increases in torque to arrive at the desired tightness is that applying large quantities of torque at one time to the bolts may cause the wood to crush and the blade track to shift.
- Wooden propellers should have a blade track no greater than 1/8 inch (3.175 mm). After arriving at the proper torque, safety the propeller retention hardware, as required.
- The torque of the propeller bolts should be re-checked after the initial flight and following the first 25 hours of operation. Thereafter, check the bolt torque every 50 hours of operation.
- The torque should also be checked when the ambient environment changes in a substantial manner (e.g., winter to summer).

# TORQUING WOODEN PROPELLERS

- To check the torque of the propeller bolts, remove safety wire, if applicable, and rotate the torque wrench in a tightening direction until the fastener begins to turn.
- If the amount of torque required to rotate the fastener is very low (e.g., approximately half to two-thirds of the prescribed torque), remove the propeller and inspect the hub area for defects (e.g., elongated holes and/or cracks).
- Such damage must be repaired by the manufacturer or an appropriately rated repair facility.
- If the torque is somewhat low (e.g., three quarters the specified torque), carefully increase the torque to the proper level.
- If the torque is with in the specified range, no action is required.
- And if the torque exceeds the prescribed range, loosen the bolts and torque to the correct limit.
- At the conclusion of the torque check, verify that the propeller track is within limits and resafety the hardware, as necessary.

# Fixed pitch, controllable pitch, constant speeding propeller;

METAL FIXED-PITCH PROPELLERS

- Metal fixed-pitch propellers are similar in general appearance to a wooden propeller, except that the sections are usually thinner.
- The metal fixed-pitch propeller is widely used on many models of light aircraft.
- Many of the earliest metal propellers were manufactured in one piece of forged **Duralumin**.
- Compared to wooden propellers,

- some were lighter in weight because of elimination of blade clamping devices, offered a lower maintenance cost because they were made in one piece,

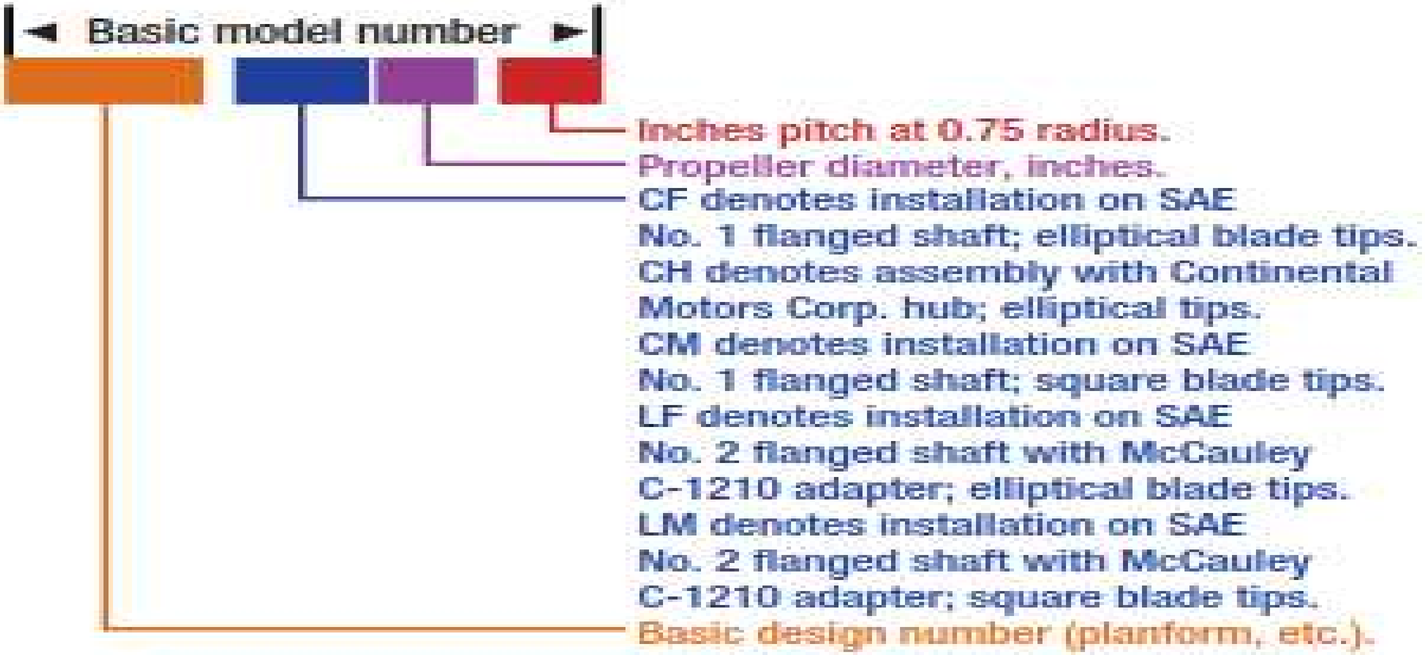
- provided more efficient cooling because of the effective pitch nearer the hub and,

- because there was no joint between the blades and the hub, the propeller pitch could be changed, within limits, by twisting the blade slightly by a propeller repair station.

- Generally, metal propellers are heavier than their wooden counterparts.

# Fixed pitch, controllable pitch, constant speeding propeller;

- Propellers of this type are now manufactured as one piece anodized aluminum alloy.
- They are identified by stamping the propeller hub with
  - the serial number,
  - model number,
  - type certificate number,
  - production certificate number,
  - and the number of times the propeller has been reconditioned.
- The complete model number of the propeller is a combination of the basic model number and suffix numbers to indicate the propeller diameter and pitch.
- An explanation of a complete model number, using the McCauley 1B90/CM propeller, is provided in Figure.




Propeller data information.

# Fixed pitch, controllable pitch, constant speeding propeller;

- STEEL PROPELLER BLADES
- A number of propeller blades are manufactured from steel. These blades are sometimes found on propellers used on larger aircraft.
- A number of World War II aircraft and large transport piston powered aircraft of that era use propellers with steel blades.
- Steel propeller blades are typically hollow to keep weight to a minimum.
- By comparison to blades made from other materials, steel propeller blades possess more heft(weight).

Cross section of steel propeller blade.

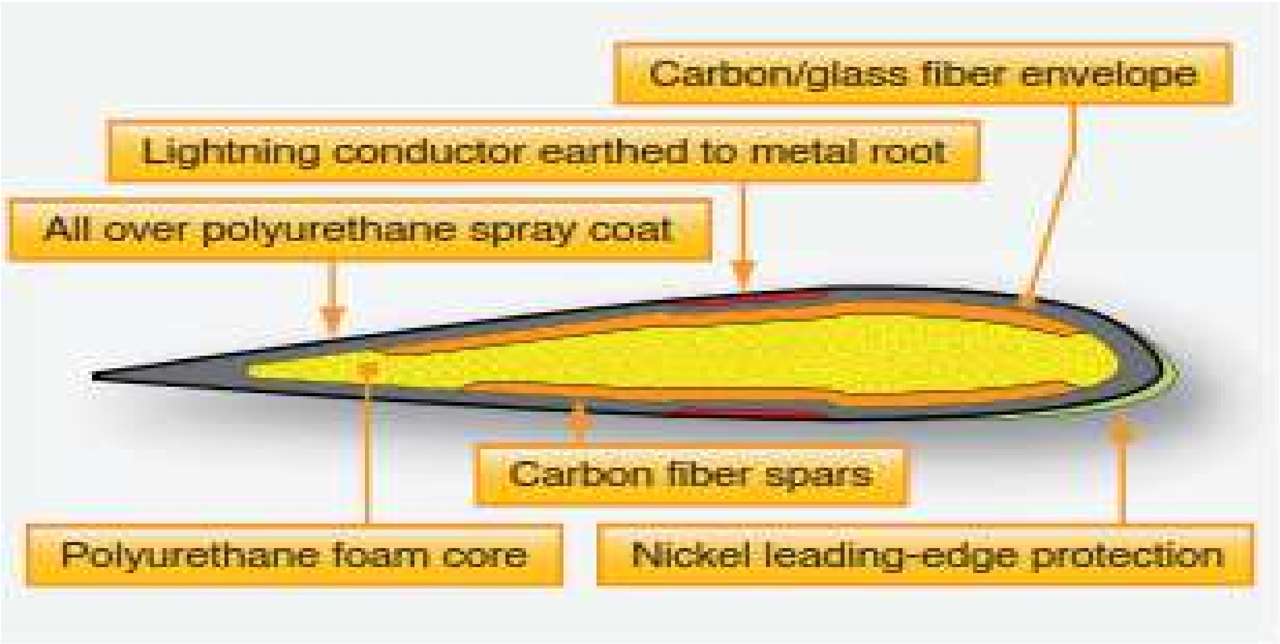
# Construction methods and materials used in wooden, composite and metal propellers;

## COMPOSITE PROPELLERS

- As with other parts of the airplane, composite materials and construction techniques have been adopted by the propeller manufacturers.
- They offer numerous advantages, especially for higher speed turboprop aircraft.
- The strength offered by composite blades in conjunction with lightweight and reduced sound levels have proven useful attributes.
- Similar to other composites used throughout the aviation industry, two essential components are utilized to produce the blades**, the matrix and the fiber** material.
- The former is similar to an epoxy and is used to keep the strands of the fiber in position.
- The fibers possess considerable tensile strength and provide vigor (strength) in terms of blade resiliency(flexibility).
- A number of propellers flown in aerobatics are composite because of their lightweight, low inertia, durability, and affordability.

# Construction methods and materials used in wooden, composite and metal propellers;

- Composite blades typically begin at the blade root where they are formed around the metal blade shank.
- Numerous layers of carbon fiber laminates are wound around a core. An attached erosion strip, when included, provides protection against blade erosion



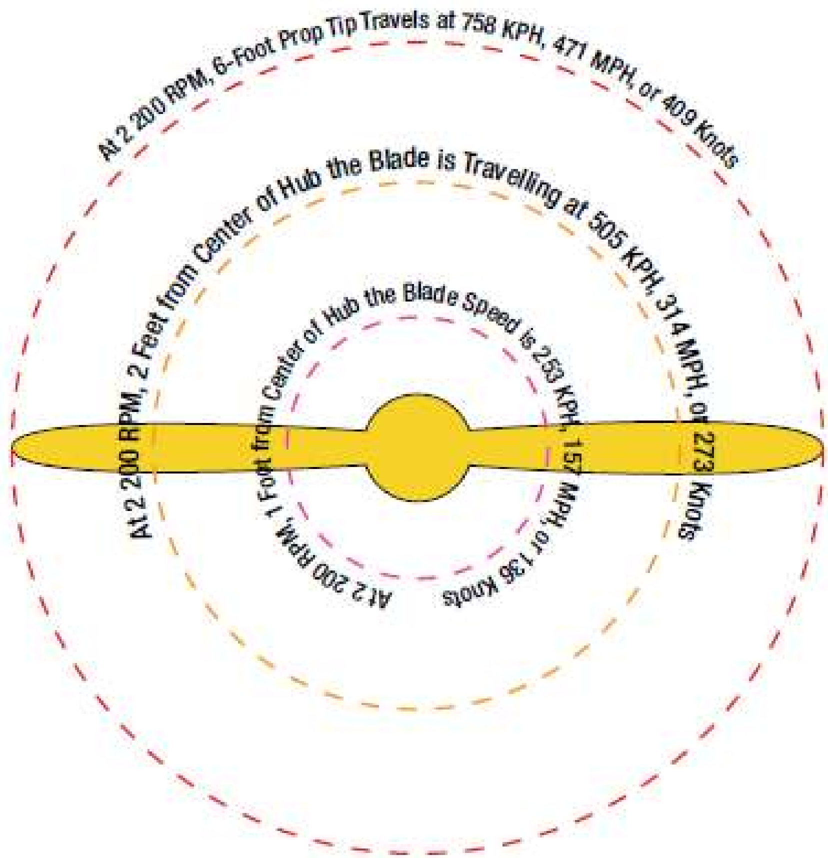

Makeup of composite propeller blade.

Cross section of composite propeller blade.

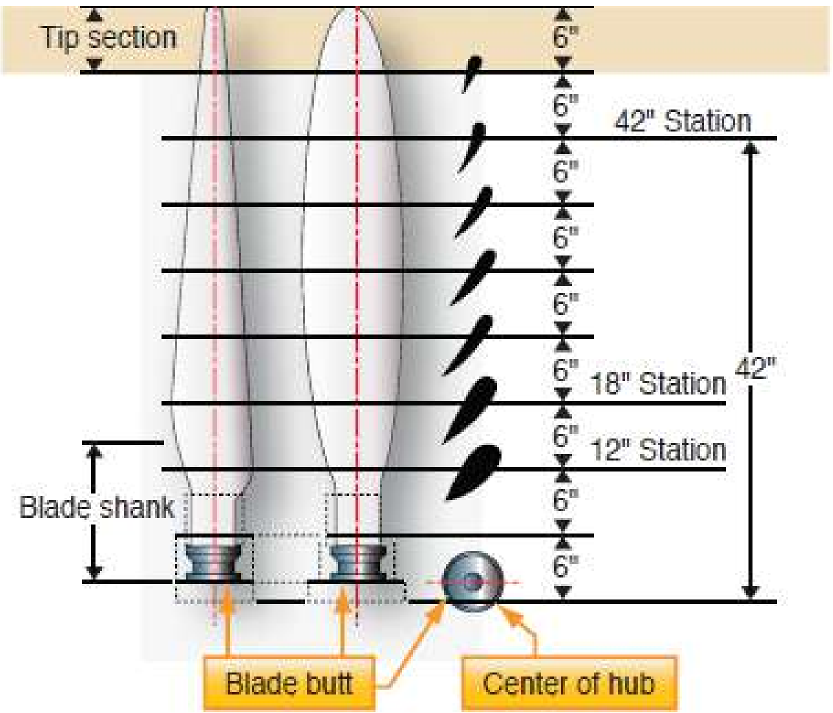
# Blade station, blade face, blade shank, blade back and hub assembly;

***BLADE STATIONS***

- Propeller blades are rotating airfoils that have a relatively complex shape when compared to wings.
- The main reason for the intricate (complex) shape is related to airspeed.
- Near the propeller hub the relative velocity between the blade section and air is comparatively slow.
- By contrast, the propeller tip experiences a high velocity with the air.
- To accommodate the difference in airspeed, a typical propeller blade will have a high blade angle near the hub and a shallow blade angle at the tip.
- An examination of a propeller blade reveals that the blade angle gradually decreases from the hub or shank area of the blade to the tip.
- The length of the chord of the propeller blade may also change moving from the hub to the tip.
- The structural need of the propeller blade near the hub may require a shape that lacks aerodynamic qualities but provides ample strength to combat the various forces placed on the propeller assembly.
- Propeller stations are often provided in six inch increments (15 cm). Note the gradual change in pitch angle and chord width.




Velocities along blade span.




Propeller blade elements demonstrating twist.

# Blade station, blade face, blade shank, blade back and hub assembly;

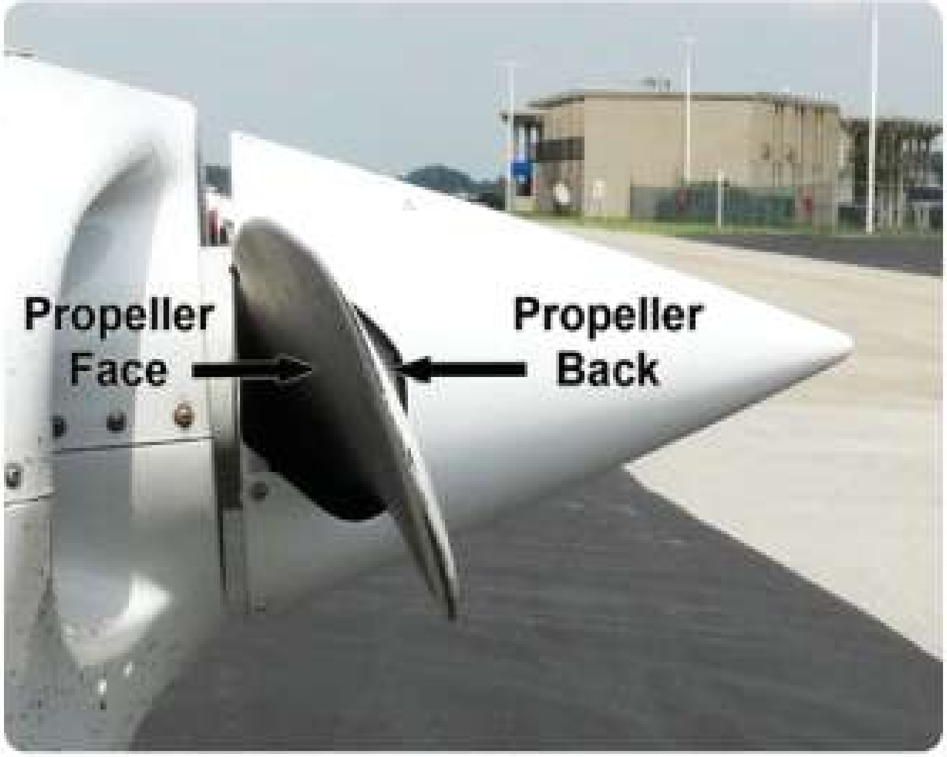
**PROPELLER HUB, SHANK, BACK, AND FACE**

- The propeller hub is designed to withstand all the forces experienced by the propeller during operation.
- On fixed-pitched units, the opposing blades connect at the hub, which is a thick, heavily built member.
- On controllable-pitch propellers, the hub accommodates the pitch change mechanisms, bearings, passageways, and necessary lubricant(s).
- In addition to retaining the blades and internal members of the pitch control mechanism, the propeller hub is attached to the crankshaft or propeller shaft.
- The thrust generated by the propeller is transmitted to the engine and ultimately to the airframe through the propeller hub.
- Some propeller models attach the spinner bulkhead, or spinner backplate, to the hub.
- The portion of the blade inserted into the hub of a controllable pitch propeller is known as the *blade butt or blade root.*
- The propeller blade shank connects the blade root or butt to the airfoil section of the propeller blade.
- The shape of the shank ranges from circular or oval to a highly cambered form.
- The shank must be capable of absorbing the loads placed upon the propeller and transmitting the thrust to the hub.
- Overshoes or boots associated with de-icing and anti-icing systems are attached to the shank of the propeller blades and extend down a measure of the blade.


Parts of a Propeller.

# Blade station, blade face, blade shank, blade back and hub assembly;

- The surface of the propeller blade known as the back is the side of the blade containing the camber or curvature.
- The propeller back is similar to the upper surface of a wing in that it generates a lower pneumatic pressure as the blade rotates.
- Where a wing produces lift, the propeller generates thrust.
- The face of the propeller blade is the surface that is relatively flat.
- As the propeller rotates, the face strikes the air. Pilots who fly single engine airplanes equipped with tractor propellers look at, or face, the face of the propeller as they operate the aircraft.




Propeller face and back.

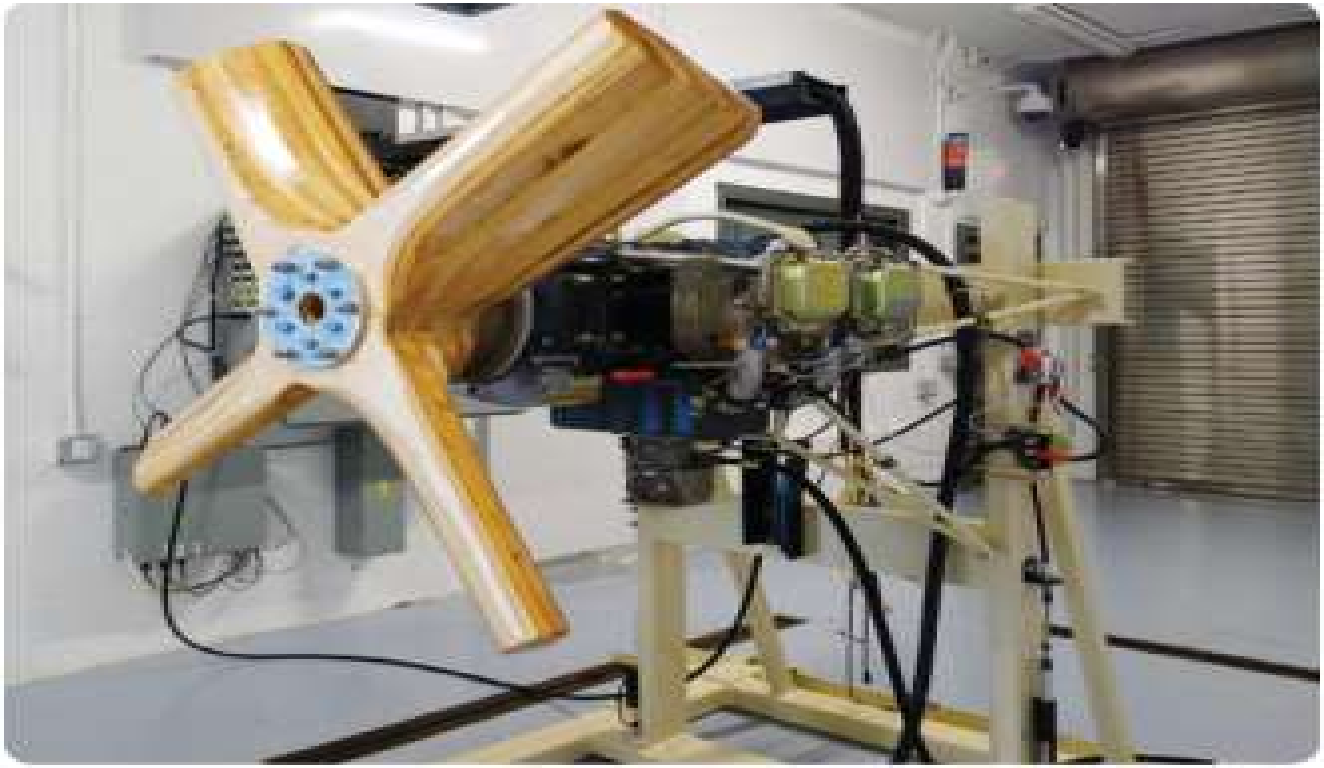
# Types of Propeller

*TYPES OF PROPELLERS*

- There are various types or classes of propellers, the simplest of which are the fixed-pitch and ground adjustable propellers.
- The complexity of propeller systems increases from these simpler forms to controllable-pitch and complex constant speed systems (automatic systems).

TEST CLUB PROPELLER

- A test club is used to test and break in reciprocating engines. They are made to provide the correct amount of load on the engine during the testing and breaking in period and not intended for flight.
- The multi blade design also provides extra cooling airflow during operation.



Club propeller used in test cell.

# FIXED-PITCH PROPELLER

FIXED-PITCH PROPELLER

- A fixed-pitch propeller has the blade pitch, or blade angle, built into the propeller.
- The blade angle cannot be changed after the propeller is built.
- Generally, this type of propeller is one piece and is constructed of wood or aluminum alloy.
- Fixed-pitch propellers are designed for best efficiency at one rotational and forward speed.
- They are designed to fit a set of conditions of both airplane and engine speeds.
- Any change in these conditions reduces the efficiency of both the propeller and the engine.
- The fixed-pitch propeller is used on airplanes of low power, speed, range, or altitude.
- Many single engine aircraft use fixed-pitch propellers and the advantages to these are less expense and their simple operation.
- This type of propeller does not require any control inputs from the pilot in flight.
- Fixed-pitch propellers are available in tractor and pusher designs.

Fixed-pitch tractor propeller.

# GROUND-ADJUSTABLE PROPELLER

GROUND-ADJUSTABLE PROPELLER

- The ground-adjustable propeller operates as a fixed-pitch propeller.
- The pitch, or blade angle, can be changed only when the propeller is not turning.
- This is done by loosening the clamping mechanism that holds the blades in place, and setting the desired pitch.
- After the clamping mechanism has been tightened, the pitch of the blades cannot be changed in flight to meet variable flight requirements.
- The ground-adjustable propeller is not often used on present day airplanes.

# CONTROLLABLE-PITCH PROPELLER

CONTROLLABLE-PITCH PROPELLER

- The controllable-pitch propeller permits a change of blade pitch, or angle, while the propeller is rotating.
- This allows the propeller to assume a blade angle that gives the best performance for particular flight conditions.
- The number of pitch positions may be limited, as with a two position controllable propeller, or the pitch may be adjusted to any angle between the minimum and maximum pitch settings of a given propeller.
- The use of controllable-pitch propellers also makes it possible to attain the desired engine rpm for a particular flight condition.

# CONTROLLABLE-PITCH PROPELLER

- This type of propeller is not to be confused with a constant-speed propeller.
- With the controllable-pitch type, the blade angle can be changed in flight, but the pilot must change the propeller blade angle directly.
- The blade angle will not change again until the pilot changes it.
- The electric propellers used on older models Beechcraft Bonanzas are examples of controllable-pitch propellers.
- To change blade angle on these electric propellers, the pilot toggles increases and decreases in propeller pitch using a switch.
- The use of a governor is the next step in the evolution of propeller development, making way for constant-speed propellers with governor systems.
- Constant-speed propeller systems are common place in higher performance general aviation airplanes and larger propeller equipped airplanes.

# CONSTANT-SPEED PROPELLERS

*CONSTANT-SPEED PROPELLERS*

- The propeller has a natural tendency to slow down as the aircraft climbs and to speed up as the aircraft dives because the load on the engine varies.
- To provide an efficient propeller, the speed is kept as constant as possible. By using propeller governors to increase or decrease propeller pitch, the engine speed is held constant.
- When the airplane goes into a climb (during cruise flight), the blade angle of the propeller decreases just enough to prevent the engine speed from decreasing.
- The engine can maintain its power output if the throttle setting is not changed.
- When the airplane goes into a dive, the blade angle increases sufficiently to prevent overspeeding and, with the same throttle setting, the power output remains unchanged.

- If the throttle setting is changed instead of changing the speed of the airplane by climbing or diving, the blade angle increases or decreases as required to maintain a constant engine rpm.
- The power output (not the rpm) changes in accordance with changes in the throttle setting. The governor controlled, constant-speed propeller changes the blade angle automatically, keeping engine rpm constant.

# *CONSTANT-SPEED PROPELLERS*

- One type of pitch changing mechanism is operated by oil pressure (hydraulically) and uses a piston and cylinder arrangement.
- The piston may move in the cylinder, or the cylinder may move over a stationary piston.
- The linear motion of the piston/cylinder is converted by several different types of mechanical linkages into the rotary motion necessary to change the blade angle.
- The mechanical connection between the piston/cylinder and propeller blades may be through gears or linkages.
- The pitch changing mechanism rotates the root of each blade.
- The propeller blades are mounted with bearings that allow them to rotate to change pitch.


Blade bearing locations.

- In most cases, the oil pressure for operating the different types of hydraulic pitch changing mechanisms comes directly from the engine lubricating system.
- When the engine lubricating system is used, the engine oil pressure is usually boosted by a pump that is integral with the governor to operate the propeller.
- The higher oil pressure (approximately 300 pounds per square inch (psi) provides a quicker blade angle change.
- A valve within the governor directs the pressurized oil for operation of the hydraulic pitch changing mechanism.
- The governors used to control hydraulic pitch changing mechanisms are geared to the engine crankshaft and are sensitive to changes in rpm.

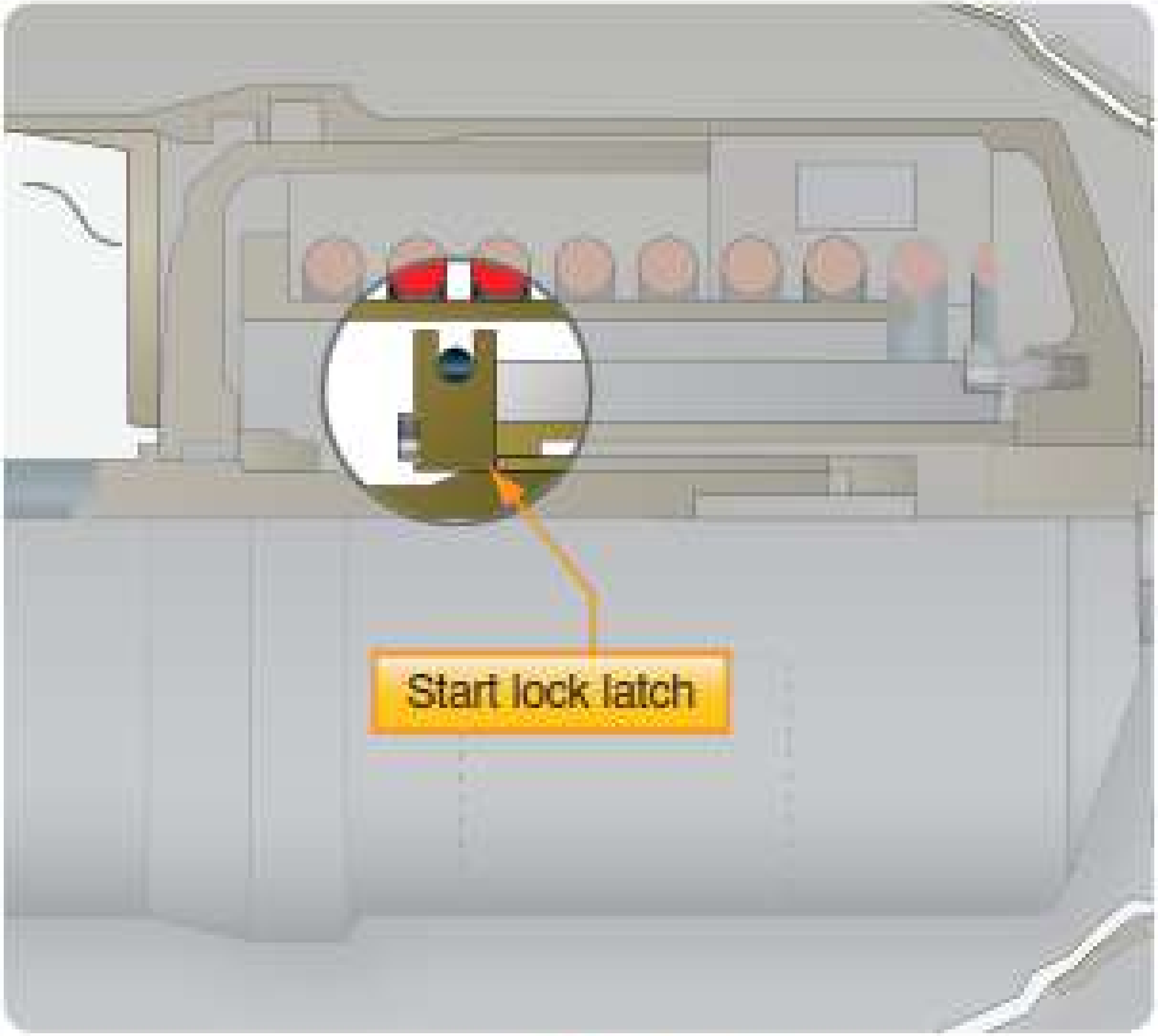
- When rpm increases above the value for which a governor is set, the governor causes the propeller pitch changing mechanism to turn the blades to a higher angle.
  - The higher pitch increases the load on the engine, and rpm decreases until it returns to the on speed rpm.
- When rpm decreases below the value for which a governor is set, the governor causes the pitch changing mechanism to turn the blades to a lower angle.
  - The load on the engine is decreased and rpm increases until it reaches the on speed rpm. Thus, a propeller governor tends to keep engine rpm constant.

- In constant speed propeller systems, the control system automatically adjusts pitch through the use of a governor, without attention by the pilot, to maintain a specific preset engine rpm within the set range of the propeller.
- For example, if engine speed increases, an overspeed condition occurs and the propeller system responds to reduce the engine rpm. The controls automatically increase the blade angle until the desired rpm has been reestablished.
- A good constant speed control system responds to such small variations of rpm that for all practical purposes, a constant rpm is maintained.
- Each constant speed propeller has an opposing force that operates against the oil pressure from the governor. On some models, counterweights mounted on the propeller blades, or associated parts, move the blades in the high pitch direction as the propeller turns.
- Other forces used to move the blades toward the high pitch direction include air pressure (contained in the front dome), springs, and aerodynamic twisting moment.


Propeller blade counterweight.

# FEATHERING PROPELLERS

- Feathering propellers are typically mounted on multi engine aircraft to reduce propeller drag to a minimum in case of one or more engine failure conditions.
- A feathering propeller is a constant speed propeller used on multi engine aircraft that has a mechanism to change the pitch to an angle of approximately 90°.
- A propeller is usually feathered when the engine fails to develop power to turn the propeller. By rotating the propeller blade angle parallel to the line of flight, the drag on the aircraft is greatly reduced. With the blades parallel to the airstream, the propeller stops turning and minimum windmilling, if any, occurs.
- The blades are held in feather by aerodynamic forces. Almost all small feathering propellers use oil pressure to take the propeller to low pitch and blade flyweights, springs, and compressed air to take the blades to high pitch.
- Since the blades would go to the feather position during shutdown, latches lock the propeller in the low pitch position as the propeller slows down at shutdown.
- These can be internal or external and are contained within the propeller hub. In flight, the latches are prevented from stopping the blades from feathering because they are held off their seat by centrifugal force.
- Latches are needed to prevent excess load on the engine at start up. If the blade were in the feathered position during engine start, the engine would be placed under an undue load during a time when the engine is already subject to wear.




Feathering latch.

# REVERSE-PITCH PROPELLERS

REVERSE-PITCH PROPELLERS

- Additional refinements, such as reverse-pitch propellers (mainly used on turboprop aircraft), are included in some propellers to improve their operational characteristics.
- Almost all reverse-pitch propellers are of the feathering type. A reverse-pitch propeller is a controllable propeller in which the blade angles can be changed to a negative value during operation.
- The purpose of the reversible pitch feature is to produce a negative blade angle that produces thrust opposite the normal forward direction.
- Typically, when the landing gear is in contact with the runway after landing, the propellers blades can be moved to negative pitch (reversed), which creates thrust opposite of the aircraft direction and slows the aircraft.
- As the propeller blades move into negative pitch, engine power is applied to increase the negative thrust. This aerodynamically brakes the aircraft and reduces ground roll after landing.
- The angle of attack encountered by the blades change as the aircraft speed changes. Reversing the propellers also reduces aircraft speed quickly on the runway just after touchdown and minimizes aircraft brake wear.
- Some aircraft are able to backup using reverse-pitch propellers.

# PROPELLER LOCATION

**TRACTOR PROPELLER**

- Tractor propellers are those mounted on the upstream end of a propeller shaft in front of the supporting structure. Most aircraft are equipped with this type of propeller.
- A major advantage of the tractor propeller is that lower stresses are induced in the propeller as it rotates in relatively undisturbed air.

**PUSHER PROPELLERS**

- Pusher propellers are those mounted on the downstream end of a propeller shaft behind the supporting structure.
- Pusher propellers are constructed as fixed or variable pitch units.
- In the early era of aviation, many airplanes used pusher propellers. Some light sport aircraft use pusher propellers.
- By placing the propeller behind the wing, airflow over the wing is straight and basically void of the spinning air mass.
- Seaplanes and amphibious aircraft have used a greater percentage of pusher propellers than other kinds of aircraft.
- On land airplanes, where propeller to ground clearance usually is less than the propeller to water clearance of watercraft, pusher propellers are subject to more damage than tractor propellers.
- Rocks, gravel, and small objects dislodged by the wheels are quite often thrown or drawn into a pusher propeller. Similarly, planes with pusher propellers are apt to encounter propeller damage from water spray thrown up by the hull during landing or takeoff airspeed.
- Consequently, the pusher propeller is commonly mounted above and behind the wings to prevent such damage.

Pusher propeller.

# CONTRA-ROTATING PROPELLERS

CONTRA-ROTATING PROPELLERS

- Contra-rotating propellers are used on a limited number of airplanes.
- The propellers are mounted on two concentric shafts that rotate in opposite directions.
- Such installations have little torque effect generated by the propellers as the torque from one unit is largely negated by the torque from the other propeller.
- Having a contra-rotating propeller installation reduces the diameter of the propeller disc that would otherwise be necessary using a single propeller. This serves to lowerthe height of the landing gear and airplane in general.

Contra-rotating propellers.

# COUNTER-ROTATING PROPELLERS

COUNTER-ROTATING PROPELLERS

- The Wright Brothers used the counter-rotating design in their early model airplanes to eliminate the torque effect of the spinning propeller mass.
- Not knowing how much impact the torque effect would have on their aspirations to succeed in producing a successful flying machine, the Brothers decided to cancel the effect by spinning each pusher propeller in opposite directions.
- Today the installation of counter-rotating propellers is used on certain model multiengine aircraft. The benefit of the counter-rotating design is especially beneficial on twin engine aircraft.
- When an engine fails or is unable to produce power on a twin engine aircraft, the pilot has to implement compensating action to sustain aircraft altitude and maintain steerage.
- One action is to feather the propeller. This reduces drag on the side of the aircraft with the troubled engine.
- Next the pilot must input corrective rudder action. Twin engine aircraft with similar rotation propellers will typically possess asymmetrical yaw between the engines.

- In other words, there will be a greater yawing action when one engine fails than the other. With clockwise rotating propellers, there will be a greater yawing action when the left engine fails.
- Consequently, the pilot needs to input greater amounts of rudder and rudder trim to compensate for a failed left engine than for a failed right engine. In such cases, the left engine is termed the “critical engine.”
- A benefit of having counter-rotating propellers is the elimination of the “critical engine” from the aircraft.
- The critical engine of a multiengine aircraft is defined as the engine whose failure would most adversely affect the performance or handling qualities of an aircraft.

Counter-rotating propellers.

# PROPELLER REMOVAL AND INSTALLATION

REMOVAL

- It provides general steps for removing and reinstalling a propeller on a flanged crankshaft or propeller shaft.
- Procedures for removing and installing propellers on splined shafts or tapered shafts are different. Always use
- the current manufacturer's information when removing and installing any propeller.
- Exercise caution when handling propellers to prevent damage to the propeller and associated components.
  - 1. Remove the spinner dome in accordance with applicable procedures. It may be necessary to index the spinner prior to removal so that the spinner may be installed in the same relative position with the propeller to maintain pre removal balance.
  - 2. Support the propeller assembly with a sling. If the same propeller is to be reinstalled and has been previously dynamically balanced, make an identifying mark (with a felt tipped pen only) on the propeller hub and a matching mark on the engine flange or propeller shaft to make sure of proper orientation during reinstallation to minimize dynamic imbalance.

- 3. Remove the lockwire and/or safetying devices. Use caution to prevent scratching the propeller during the removal of the lockwire. Remove the hardware securing the propeller to the shaft.
- It may be necessary to use special wrenches.
- Do not allow the tools to damage the crankshaft, engine case, or propeller.

- CAUTION: Remove the propeller from the mounting flange with care to prevent damaging the propeller mounting studs. Using the support sling, remove the propeller from the engine. Smaller propellers may be removed without a sling using technicians to grapple with the unit. On constant-speed propeller models, be prepared to capture oil that will drain as the propeller is separated from the propeller shaft.

- 4. Place the propeller on a suitable cart or fixture for transport or storage

INSTALLATION

- Most flanged propellers have six studs configured in a four inch circle. Dowel pins may also be used to absorb torque during operation and index the propeller with respect to the propeller shaft.
- Perform the applicable steps to clean the engine flange and propeller flange with quick drying stoddard solvent or methyl-ethyl ketone (MEK). Observe safety precautions when handling such chemicals.
- Install the O-ring in the O-ring groove in the hub bore or on propeller shaft.
- NOTE: When the propeller is received from the factory, the O-ring has usually been installed or is included with the shipment.
- With a suitable support, such as a crane hoist or similar equipment or adequate personnel, carefully move the propeller assembly to the engine mounting flange in preparation for installation.
- Install the propeller on the engine flange. Make certain to align the dowel pins, if used, with the corresponding holes in the engine mounting flange. As the attachment studs are longer than the dowel pins, exercise care when threading the studs through the mounting holes to avoid damage to the threads.
- The propeller may be installed on the engine flange in a given position, or 180° from that position. If reinstalling a propeller that has been dynamically balanced, align the propeller to match the original installation position.
- Check the engine and airframe manuals to determine if either manual specifies a propeller mounting position.

Index mark on spinner bulkhead shown on left image and index mark on spinner shown on right image. Technicians should align the two marks before installing the spinner.

- CAUTION: Tighten nuts evenly to avoid hub damage.
- Install the propeller mounting hardware per manufacturer’s instructions.
- Torque the propeller mounting nuts or bolts in accordance with the proper specifications and safety wire the studs or bolts in pairs (if required by the aircraft maintenance manual). If safety wire is not used, install the appropriate safetying device. Be careful to prevent slippage of wrenches during the torquing process.
- Following the installation of the propeller, the technician must connect any additional items included with the propeller system, such as wires for the propeller de-icing system. If equipped, the spinner must be installed.
- Spinners range from small simple units retained by a single screw, as shown on the wooden propeller in Figure to large spinners.
- As spinners are part of the rotating mass during operation, technicians should index the spinner in relation to the spinner bulkhead so that during reinstallation the two may be reunited in the same relative position.
- Some manufacturers index the spinner and bulkhead at the factory. Often technicians will have to install their own index marks (e.g., a piece of tape that spans the spinner and bulkhead).
- Reinstalling the spinner in a different position may result in vibration during operation.
- It will be necessary to perform a post installation test of the propeller. During the test the technician should ensure proper rpm attainment and, if the propeller is controllable, check operation including feathering and reversing, as appropriate.
- After the test, the technician should check for oil leaks on controllable-pitch models and correct any defects. Next, the technician should complete the appropriate paperwork.

# PROPELLER CLEARANCES

PROPELLER CLEARANCES

- During operation, the whirling propeller is capable of causing damage to itself, the engine, and surrounding objects.
- Generally, when the aircraft experiences a propeller strike, the propeller and engines will need to be inspected and repaired. In extreme cases, the engine and propeller will need to be replaced.
- To minimize the risk of encountering propeller strikes, an array of clearances between the propeller, ground, water, and structure has been established.
- Each set of regulations will specify the appropriate propeller clearances.
- In the U.S., the minimum clearance between the tip of the propeller and ground is **seven inches (18 cm)** for nose wheel aircraft and **nine inches (23 cm)** for tail wheel aircraft.
- These clearances are when the aircraft is in its normal takeoff or taxing attitude, whichever is most critical. Aft mounted propellers must be designed so that the propeller will not contact the ground when the airplane is at its maximum pitch attitude during normal takeoffs and landings.
- There is a requirement of at least **18 inches (46 cm)** of clearance between the propeller and water on aircraft that land and takeoff from the water.
- A requirement of at least **one inch (2.54 cm)** of clearance in a radial direction is required from the tip of the propeller to the structure of the aircraft. Additional radial clearance may be required to prevent detrimental vibrations.
- There must be a minimum of ½ inch (1.27 cm) clearance between any part of the propeller blade and any stationary part of the aircraft. Positive clearance between the rotating parts of the propeller and spinner and stationary parts of the airplane is required.

# 17.3 Propeller Pitch Control

# Speed control and pitch change methods, mechanical and electrical/ electronic

# Feathering and reverse pitch;

# Overspeed protection

# 17.4 Propeller Synchronising

# Synchronising and synchrophasing equipment

# 17.5 Propeller Ice Protection

# Fluid and electrical de-icing equipment.

# 17.6 Propeller Maintenance

# Static and dynamic balancing;

# Blade tracking;

# Assessment of blade damage, erosion, corrosion, impact damage, delamination

# Propeller treatment/repair schemes;

# Propeller engine running

# 17.7 Propeller Storage and Preservation

# Propeller preservation and depreservation