School of Aeronautics (Neemrana)

Question Paper For Internal Assessment Examination (Theory) - Credit 3)

[Approved By AICTE / Director General of Civil Aviation, Affiliated to RTU & BTU]

Instructions For Students / Faculty
Mid Term I (Total 60 Marks, 2 HRS. Syllabus From Beginning Of Session)

- Part A: Total number of questions to be given are five, each carrying 3 marks and are compulsory to attend. There is no choice. They are short answer type questions **(Not More Than 25 Words For Both Question & Answer)**, no objective type or fill in the blanks. Total 15 marks.
- Part B: Total number of questions to be given are six, out of which student has to answer any four. They are long answer type (**Not More Than 50 Words For Question)**, each carrying 6 marks. Total 24 marks.
- Part C: Total number of questions to be given are four, out of which student has to answer any three. They are numerical answer type / fully elaborative type (**Not More Than 70 Words For Question)***, each carrying 7 marks. Total 21 marks.

Mid Term II & III (Total 90 Marks, 2.5 HRS. Syllabus From Beginning Of Session)

- Part A: Total number of questions to be given are ten, each carrying 2 marks and are compulsory to attend. There is no choice. They are short answer type questions **(Not More Than 25 Words For Both Question & Answer)**, no objective type or fill in the blanks. Total 20 marks
- Part B: Total number of questions to be given are seven, out of which student has to answer any five. They are long answer type (**Not More Than 50 Words For Question)**, each carrying 6 marks. Total 30 marks.
- Part C: Total number of questions to be given are five, out of which student has to answer any four. They are numerical answer type / fully elaborative type (**Not More Than 70 Words For Question)***, each carrying 10 marks. Total 40 marks.

*** LIST OF ELABORATIVE THEORY QUESTION SUBJECTS**: Communication Skills, Human Values, Technical Communication, Managerial Economics and Financial, Aircraft Materials and Processes, Aircraft Systems, Aircraft Maintenance Practices, Avionics-I, Aircraft Rules and Regulation, Wind Tunnel Techniques, Maintenance of Airframe and System, Helicopter Theory, Avionics-II, Maintenance of Power Plant and System, Unmanned Aerial Vehicles & Systems (UAV), Space Mission Design & Optimization, CAD, Airlines and Airport Management.

FACULTY MEMBERS, PLEASE ENSURE EXCEPT ABOVE LISTED SUBJECTS, NO THEORITICAL ELABORATIVE QUESTION SHOULD BE GIVEN IN PART 'C' OF QUESTION PAPER

Question Paper & Student Details

Mid Term*	Mid Term 1	**Date of Submission of QP**	02/09/2019
Name of Faculty*	Maris Brightson C L	**Date of Examination***	10/09/2019
Subject*	7AN6.2- Helicopter theory (Old)	**Course***	B.Tech (Aeronautical Enginee...
Batch*	Eleventh (11)	**Semest...**	Semester : 7
Email Id of Faculty:*	marisbrightsoncl@gmail.com	**Phone Number of Faculty***	805 667 7643

Student Name | **Student Reg No.**

Part A

Question : 1* What are the rotor systems that are used in helicopters

Lesson Plan* 3 **Topic*** Types of rotor systems **Source*** Principles of helic

Question : 2* Define Blow Back (or) Flap Back

Lesson Plan* 5 **Topic*** Dissymmetry of lift **Source*** Principles of helic

Question : 3* Define Induced flow & Rotational Airflow

Lesson Plan* 4 **Topic*** Airflow in rotor blades **Source*** Principles of helic

Question : 4* Draw and label the basic parts of a helicopter

Lesson Plan* 1 **Topic*** Introduction **Source*** Principles of helic

Question : 5*	Define Angle of Incidence

Lesson Plan*	4	**Topic***	Airflow in rotor blades	**Source***	Principles of helicc

Question : 6	

Lesson Plan		**Topic**		**Source**	

Question : 7	

Lesson Plan		**Topic**		**Source**	

Question : 8	

Lesson Plan		**Topic**		**Source**	

Question : 9	

Lesson Plan		**Topic**		**Source**	

Question : 10	

Lesson Plan		**Topic**		**Source**	

Part B

Question : 1*

Explain about Flapping, Feathering and Lead-Lag with suitable diagram

Lesson Plan* 3 **Topic*** Movements in rotor blac **Source*** Principles of helicc

Question : 2*

Explain about types of rotor systems in helicopters with illustrative diagram

Lesson Plan* 3 **Topic*** Types of rotor systems **Source*** Principles of helicc

Question : 3*

What are the different types of airfoils? What type of airfoil is preferred for helicopter blades? State the reason for the preference of particular airfoil.

Lesson Plan* 4 **Topic*** Airflow in rotor blades **Source*** Principles of helicc

Question : 4*

Define Coning angle. Explain in detail about coning with suitable diagram.

Lesson Plan* 6 **Topic*** Centrifugal force and co **Source*** Principles of helicc

Question : 5*

What are the controls that are used for operation of helicopter? Explain their functions in detail.

Lesson Plan* 2 **Topic*** Basic parts and controls **Source*** Principles of helicc

Question : 6*	What is hovering? What are the ground effects during hovering? What ground effect is suitable for efficient hovering?				
Lesson Plan*	6	**Topic***	Ground effects during h	**Source***	Principles of helic
Question : 7					
Lesson Plan		**Topic**		**Source**	

Part C

Question : 1*	Explain in detail about Dissymmetry of Lift with illustrative diagrams.				
Lesson Plan*	5	**Topic***	Dissymmetry of lift	**Source***	Principles of helic
Question : 2*	Explain about Gyroscopic Precession with illustrative diagrams.				
Lesson Plan*	7	**Topic***	Gyroscopic Precession	**Source***	Principles of helic

Question : 3*	What is Autorotation? Explain in detail about Aerodynamics of Autorotation.				
Lesson Plan*	7	**Topic***	Autorotation	**Source***	Principles of helic(
Question : 4*	What is Translational tendency? How it is corrected? Explain about Translational lift in detail.				
Lesson Plan*	8	**Topic***	Translating Tendency	**Source***	Principles of helic(
Question : 5					
Lesson Plan		**Topic**		**Source**	

Upload Scanned Document In Case of Numerical or Diagram for any of the above question

Mention question number with relevant fig / numerical / equations. Max 150 KB

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I have scrutinized the question paper. There is no spelling mistake or any type of irrelevant question.

Answer Sheet Details	
Mid Term	Mid Term 1
Name of Faculty	Maris Brightson C L
Date of Submission of QP	17/09/2019
Subject	7AN5-13- Helicopter Theory (New)
Batch	Eleventh (11)
Email Id of Faculty:	marisbrightsoncl@gmail.com
Date of Examination	10/09/2019
Course	B.Tech (Aeronautical Engineering)
Semester	Semester : 7
Phone Number of Faculty	805-667-7643

Part A	
Question : 1	1. Fully Articulated 2. Semi rigid 3. Rigid
Question : 2	Dissymmetry of lift is controlled by flapping of rotor blades. Due to the combined effect of dissymmetry of lift and flapping the rotor blades will move towards upward direction which causes blow back. It can be corrected by cyclic feathering.
Question : 3	Induced flow is defined as the mass of air that is forced down by the rotor action. As a blade rotates it creates a relative airflow onto its leading edge, called Vr (velocity as a result of rotation). At the rotor hub Vr is slower than that at the tip, where the airflow is quite fast.
Question : 4	1. Main rotor blade 2. Rotor mast 3. Transmission system 4. Fuselage 5. Tail boom 6. Tail rotor 7. Landing skid 8. Power plant
Question : 5	The angle between the chord of the blade and the plane of rotation is known as the blade angle or pitch angle, and is controlled through the collective pitch control. If the pilot pulls the collective lever up blade angle increases, and if the pilot pushes the collective lever down, the blade angle decreases.
Question : 6	
Question : 7	
Question : 8	
Question : 9	
Question : 10	
Part B	

Question : 1	Flapping: Movement of a blade in the vertical sense relative to the plane of rotation. Feathering: The movement of the blade about its feathering axis (which results in pitch angle changes). Lead-lagging (dragging): Movement of a blade forward or aft in the plane of rotation.
Question : 2	Rotor Systems : 1.Fully articulated rotor: This system allows blades to flap, feather and lead-lag (drag). Generally these movements are allowed through hinges or bearings. It is common for rotors with more than two blades to use the fully articulated principle. 2.Semi-rigid rotor. This system allows blade freedom to flap and feather but not to lead-lag. This rotor utilizes the “see-saw” principle where one blade flaps up while the other flaps down around a gimbal ring arrangement, also referred to as a teetering hinge. It is a common system used in two-bladed rotors. Although lead-lag forces apply in this system just as they do in fully articulated rotors, lead-lag is usually absorbed within the blades themselves. Some semi-rigid systems utilize flexible units at the blade attachment point, and/or a flexible mast to absorb a degree of lead-lag forces. 3.Rigid rotor: This system allows the blade freedom to feather only, it does not allow for freedom to flap or lead-lag (drag). Control loads in this type of rotor are very high and stability is difficult to achieve. In advanced rigid rotor systems, it is usual to incorporate computer systems to facilitate ease of control and stability.
Question : 3	Airfoil are generally of two types. They are Symmetrical Airfoil and Non-Symmetrical Airfoil. Manufacturers of helicopter blades now build blades with both symmetrical and non-symmetrical shapes. Although the symmetrical shape has the advantage of a static center of pressure, it is not a good lift producer because its maximum lift coefficient (CLmax) is not high. The introduction of high stress-resistant materials has resulted in the use of blades that are non-symmetrically shaped. Tail rotor blades, which are able to absorb more stress and twist forces, are often non symmetrical. The center of pressure in non symmetrical airfoils moves forward as the angle of attack increases and it moves rearward as the angle of attack decreases. Both movements are along the chord line, which is the straight line connection between the leading edge and trailing edge of the airfoil. By convention, a forward movement of the center of pressure is referred to as an unstable movement, while a rearward movement is referred to as a stable movement.

Question : 4	When the rotor blades are at rest, they droop due to their weight and span. In fully articulated systems, they rest against a static or droop stop which prevents the blade from descending so low it will strike the aircraft (or ground!). When the rotor system begins to turn, the blade starts to rise from the static position because of the centrifugal force. At operating speed, the blades extend straight out even though they are at flat pitch and are not producing lift. As the helicopter develops lift during takeoff and flight, the blades rise above the "straight out" position and assume a coned position. Amount of coning depends on RPM, gross weight, and G-Forces experienced during flight. If RPM is held constant, coning increases as gross weight and G-force increase. If gross weight and G forces are constant, decreasing RPM will cause increased coning. Excessive coning can occur if RPM gets too low, gross weight is too high, or if excessive G-forces are experienced. Excessive coning can cause undesirable stresses on the blade and a decrease of total lift because of a decrease in effective disk area. The vertical force is lift produced when the blades assume a positive angle of attack. The horizontal force is caused by the centrifugal force due to rotation. Since one end of the blade is attached to the rotor shaft, it is not free to move. The other end can move and will assume a position that is the resultant of the forces acting on it. The blade position is coned and is a resultant of the two forces, lift and centrifugal force, acting on it.
Question : 5	1. Collective Control - Pulling the collective lever up moves the swashplate vertically so that all blades obtain the same increase in blade angle. Similarly, pushing the collective down decreases the blade angle to all blades. Variations in blade angle change the amount of total rotor thrust produced. Accordingly, changes in collective cause changes in total rotor thrust (but they do not alter total rotor thrust orientation). The actual vertical movement of the swashplate associated with up collective depends on where the pitch horn is attached to the blade. If the attachment point was at the trailing edge of the blade the swashplate must move down to increase blade angle. Pitch horn location varies from aircraft to aircraft. An increase in all blade angles (up collective), under most conditions, increases rotor drag and may decrease rotor rpm. To facilitate maintenance of rotor rpm, a correlating unit (a cam-link arrangement) is fitted between the collective control and the throttle butterfly, increasing power automatically and avoiding a loss of rotor rpm whenever collective is pulled up. In most modern helicopters a governor is fitted to automatically maintain the required engine rpm and therefore rotor rpm. 2. Cyclic Control - Moving the cyclic control left/right, fore/aft or any combination thereof tilts the swashplate, which changes the blade angle of individual blades. For instance, in a two-bladed rotor, moving the cyclic forward decreases the blade angle on the right blade and increases the blade angle on the left blade. Although moving cyclic alters the tilt of the total rotor thrust, the amount of total rotor thrust is not affected. Cyclic merely points the total rotor thrust in any required direction, it doesn’t increase or decrease it.

Question : 6	Hovering is the term applied when a helicopter maintains a constant position at a selected point, usually a few feet above the ground. For a helicopter to hover, the main rotor must supply lift equal to the total weight of the helicopter. With the blades rotating at high velocity, an increase of blade pitch (angle of attack) would induce the necessary lift for a hover. The forces of lift and weight reach a state of balance during a stationary hover. The high power requirement needed to hover out of ground effect is reduced when operating in ground effect. Ground effect is a condition of improved performance encountered when operating near (within 1/2 rotor diameter) of the ground. It is due to the interference of the surface with the airflow pattern of the rotor system, and it is more pronounced the nearer the ground is approached. Increased blade efficiency while operating in ground effect is due to two separate and distinct phenomena. First and most important is the reduction of the velocity of the induced airflow. Since the ground interrupts the airflow under the helicopter, the entire flow is altered. This reduces downward velocity of the induced flow. The result is less induced drag and a more vertical lift vector. The lift needed to sustain a hover can be produced with a reduced angle of attack and less power because of the more vertical lift vector. When operating in ground effect, the downward and outward airflow pattern tends to restrict vortex generation. This makes the outboard portion of the rotor blade more efficient and reduces overall system turbulence caused by ingestion and recirculation of the vortex swirls. Rotor efficiency is increased by ground effect up to a height of about one rotor diameter for most helicopters.
Question : 7	
Part C	

Question : 1	Dissymmetry of lift is the difference in lift that exists between the advancing half of the rotor disk and the retreating half. It is caused by the fact that in directional flight the aircraft relative wind is added to the rotational relative wind on the advancing blade, and subtracted on the retreating blade. The blade passing the tail and advancing around the right side of the helicopter has an increasing airspeed which reaches maximum position. As the blade continues, the airspeed reduces to essentially rotational airspeed over the nose of the helicopter. Leaving the nose, the blade airspeed progressively decreases and reaches minimum airspeed position. The blade airspeed then increases progressively and again reaches rotational airspeed as it passes over the tail. Since lift increases as the square of the airspeed, a potential lift variation exists between the advancing and retreating sides of the rotor disk. This lift differential must be compensated for, or the helicopter would not be controllable. To compare the lift of the advancing half of the disk area to the lift of the retreating half, the lift equation can be used. In forward flight, two factors in the lift formula, density ratio and blade area, are the same for both the advancing and retreating blades. The airfoil shape is fixed for a given blade. The only remaining variables are changes in blade angle of attack and blade airspeed. These two variables must compensate for each other during forward flight to overcome dissymmetry of lift. Two factors, rotor RPM and aircraft airspeed, control blade airspeed during flight. Both factors are variable to some degree, but must remain within certain operating limits. Angle of attack remains as the one variable that may be used by the pilot to compensate for dissymmetry of lift. The pitch angle of the rotor blades can be varied throughout their range, from flat pitch to the stalling pitch angle, to change angle of attack and to compensate for lift differential. When made with the blade feathering mechanism, the changes are called cyclic feathering. Pitch changes are made to individual blades independent of the others in the system and are controlled by the pilot's cyclic pitch control.
Question : 2	Gyroscopic precession is a phenomenon occurring in rotating bodies in which an applied force is manifested 90 degrees later in the direction of rotation from where the force was applied. Although precession is not a dominant force in rotary-wing aerodynamics, it must be reckoned with because turning rotor systems exhibit some of the characteristics of a gyro. A downward force applied to the disk at point A results in a downward change in disk attitude at point B. And upward force applied at Point C results in an upward change in disk attitude at point D. Forces applied to a spinning rotor disk by control input or by wind gusts will react as follows: This behavior explains some of the fundamental effects occurring during various helicopter maneuvers. For example, the helicopter behaves differently when rolling into a right turn than when rolling into a left turn. During roll into a left turn, the pilot will have to correct for a nose down tendency in order to maintain altitude. This correction is required because precession causes a nose down tendency and because the tilted disk produces less vertical lift to counteract gravity. Conversely, during a roll into a right turn, precession will cause a nose up tendency while the tilted disk will produce less vertical lift. Pilot input required to maintain altitude is significantly different during a right turn than during a left turn, because gyroscopic precession acts in opposite directions for each.

Question : 3

During powered flight, the rotor drag is overcome with engine power. When the engine fails, or is deliberately disengaged from the rotor system, some other force must be used to sustain rotor RPM so controlled flight can be continued to the ground. This force is generated by adjusting the collective pitch to allow a controlled descent. Airflow during helicopter descent provides the energy to overcome blade drag and turn the rotor. When the helicopter is descending in this manner, it is said to be in a state of autorotation. In effect the pilot gives up altitude at a controlled rate in return for energy to turn the rotor at an RPM which provides aircraft control. As altitude decreases, potential energy is converted to kinetic energy and stored in the turning rotor. The pilot uses this kinetic energy to cushion the touchdown when near the ground. Most autorotations are performed with forward airspeed. For simplicity, the following aerodynamic explanation is based on a vertical autorotative descent (no forward airspeed) in still air. Under these conditions, the forces that cause the blades to turn are similar for all blades regardless of their position in the plane of rotation.

Autorotations may be divided into three distinct phases; the entry, the steady state descent, and the deceleration and touchdown. Each of these phases is aerodynamically different than the others. Entry into autorotation is performed following loss of engine power. Immediate indications of power loss are rotor RPM decay and an out-of-trim condition. Rate of RPM decay is most rapid when the helicopter is at high collective pitch settings. To successfully perform an autorotative landing, the pilot must reduce airspeed and rate of descent just before touchdown. Both of these actions can be partially accomplished by moving the cyclic
control to the rear and changing the attitude of the rotor disk with relation to the relative wind. The attitude change inclines the total force of the rotor disk to the rear and slows forward speed. As a result, total rotor lifting force is increased and rate of descent is reduced. RPM also increases when the total aerodynamic force vector is lengthened, thereby increasing blade kinetic energy available to cushion the touchdown. After forward speed is reduced to a safe landing speed, the helicopter is placed in a landing attitude as collective pitch is applied to cushion the touchdown.

Question : 4

During hovering flight, the single rotor helicopter has a tendency to drift laterally to the right due to the lateral thrust being supplied by the tail rotor. The pilot may prevent right lateral drift of the helicopter by tilting the main rotor disk to the left. This lateral tilt results in a main rotor force to the left that compensates for the tail rotor thrust to the right. Helicopter design usually includes one or more features which help the pilot compensate for translating tendency.
• Flight control rigging may be designed so the rotor disk is tilted slightly left when the cyclic control is centered.
• The collective pitch control system may be designed so that the rotor disk tilts slightly left as collective pitch is increased to hover the aircraft.
• The main transmission may be mounted so that the mast is tilted slightly to the left when the helicopter fuselage is laterally level.

The efficiency of the hovering rotor system is improved with each knot of incoming wind gained by horizontal movement or surface wind. As the incoming wind enters the rotor system, turbulence and vortexes are left behind and the flow of air becomes more horizontal. All of these changes improve the efficience of the rotor system and improve aircraft performance. Improved rotor efficience resulting from directional flight is called translational lift.

As the helicopter speed increases, translational lift becomes more effective and causes the nose to rise, or pitch up (sometimes called blowback). This tendency is caused by the combined effects of dissymmetry of lift and transverse flow. Pilots must correct for this tendency in order to maintain a constant rotor disk attitude that will move the helicopter through the speed range where blowback occurs. If the nose is permitted to pitch up while passing through this speed range, the aircraft may also tend to roll to the right. When the single main rotor helicopter transitions from hover to forward flight, the tail rotor becomes more aerodynamically efficient. Efficiency increases because the tail rotor works in progressively less turbulent air as speed increases. As tail rotor efficiency improves, more thrust is produced. This causes the aircraft nose to yaw left if the main rotor turns counterclockwise. During a takeoff where power is constant, the pilot must apply right pedal as speed increases to correct for the left yaw tendency.

Question : 5

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I have scrutinized the answer sheet. There is no spelling mistake or any type of irrelevant answers.

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