J.J COLLEGE OF ENGINEERING AND TECHNOLOGY

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Accredited by NAAC with A Grade

SOWDAMBIKAA GROUP OF INSTITUTIONS

ESTD. 1994

# DEPARTMENT OF AERONAUTICAL ENGINEERING

## CAE339 – INDUSTRIAL AERODYNAMICS

## QUESTION BANK

## R-2021

## INSTITUTE VISION & MISSION

**VISION:**

To become a globally recognized "Centre of Academic Excellence" providing Quality Education to all students.

**MISSION:**

To provide Quality Education in the fields of Engineering, Management, Information, Technology and other Engineering areas.

## DEPARTMENT VISION & MISSION

**VISION:**

To prepare technically skilled and competent intellectual professional graduates to meet the challenges in the Aerospace industry.

**MISSION:**

**M1:** To produce technologically competent graduates to be front-runner in their profession.

**M2:** To provide state-of-the-art facilities and laboratories so as to enhance excellence in teaching and learning process.

**M3:** To provide need-based quality training programmes in the field of the Aerospace industry.

**M4:** Enhance the students' sound knowledge in the latest technologies by organizing technical programs and encouraging students to make them present papers and participate in technical events.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

| | |
|---|---|
| **PEO1** | Apply knowledge in emerging and varied areas of Aerospace Engineering for higher studies, research, employment and product development. |
| **PEO2** | Communicate their skills and have a sense of responsibility to protect the environment and have ethical conduct towards their profession and commitment to serve the society. |
| **PEO3** | Exhibit managerial skills and leadership qualities while understanding the need for lifelong learning to be competent professionals. |

## PROGRAM OUTCOMES (POs):

| | |
|---|---|
| **PO1** | **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems. |
| **PO2** | **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions Using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO3** | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations. |
| **PO4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including the design of experiments, Analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations. |
| **PO6** | **The engineer and society:** Apply to reason in formed by the contextual Knowledge to assess societal, health, safety, legal and cultural issues and the Consequent responsibilities relevant to the professional engineering practice. |
| **PO7** | **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO8** | **Ethics:** Apply ethical principles and commit to professional ethics and Responsibilities and norms of the engineering practice. |

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| **PO9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in Diverse teams, and in multidisciplinary settings. |
| **PO10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO11** | **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply These to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to Engage in in dependent and life-long learning in the broadest context of technological change. |

## PROGRAM SPECIFIC OUTCOMES (PSOs):

| | |
|---|---|
| **PSO1** | To analyze, design and develop solutions by applying foundational concepts of Aeronautical engineering. |
| **PSO2** | To apply design principles and best practices for developing quality products for scientific and business applications. |
| **PSO3** | An engineering acumen in identifying, formulating, analyzing and solving complex engineering problems. |

| CAE339 | INDUSTRIAL AERODYNAMICS | L T P C |
|---|---|---|
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COURSE OBJECTIVES:

- To learn the concepts of non-aeronautical usages of aerodynamics
- To introduce the topic of wind energy collectors
- To impart concepts of analysing vibrations during flow
- To the learn the concepts of Atmospheric boundary layer
- To introduce the basics of Flow induced vibrations

**UNIT I ATMOSPHERE 9**

Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows.

**UNIT II WIND ENERGY COLLECTORS 9**

Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

**UNIT III VEHICLE AERODYNAMICS 9**

Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics of trains and Hovercraft.

**UNIT IV BUILDING AERODYNAMICS 9**

Blocks, Special problems of tall buildings, building codes, Building ventilation and architectural aerodynamics.

**UNIT V FLOW INDUCED VIBRATIONS 9**

Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter

**TOTAL: 45 PERIODS**

## COURSE OUTCOMES(COs)

| On completion of this course, the students expected to be able to: | |
|---|---|
| **CO1** | Use of aerodynamics for non- aerodynamics such as vehicle, building. |
| **CO2** | Solve the problems and able to analyze vibrations during flow. |
| **CO3** | Identify the Atmospheric boundary layer and applications of wind energy collectors. |
| **CO4** | Analyse the aerodynamics of road vehicles and problems of flow induced vibrations. |
| **CO5** | Analyse the aerodynamics of buildings and problems of flow induced vibrations. |

## CO's – PO's & PSO's MAPPING

| Correlation of COs with POs / PSOs | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
| **CO1** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **CO2** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **CO3** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **CO4** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **CO5** | 1 | 2 | 2 | 2 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **AVG** | **1** | **2** | **2** | **2** | **2** | - | - | - | - | - | - | - | **2** | **1** | **1** |
| **3 – High; 2 – Medium; 1 – Low; - - No correlation** | | | | | | | | | | | | | | | |

**TEXT BOOKS:**


1. M. Sovran (Ed), "Aerodynamics and drag mechanisms of bluff bodies and Road vehicles", Plenum press, New York, 1978.
2. Sachs. P., "Winds forces in Engineering", Pergamon Press, 1978


**REFERENCES BOOKS:**


1. Blevins. R.D., "Flow Induced Vibrations", Van Nostrand, 1990.
2. Calvent. N.G., "Wind Power Principles", Charles Griffin & Co., London, 1979.

## UNIT– I

## ATMOSPHERE

| PART–A | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Define aerodynamic roughness length and gradient layer for an atmospheric boundary layer. | CO1 | Remember | Low |
| 2 | Write power-law that are used to represent an atmospheric boundary layer. | CO1 | Understand | Medium |
| 3 | Define the terrain influence in wind turbulence. | CO1 | Remember | Low |
| 4 | What is meant by Coriolis force? | CO1 | Understand | Low |
| 5 | Define Wind. | CO1 | Remember | Low |
| 6 | What are the types of winds? | CO1 | Understand | Low |
| 7 | What is atmospheric boundary layer? | CO1 | Understand | Low |
| 8 | Define wind profile. | CO1 | Remember | Low |
| 9 | What is power law? | CO1 | Understand | Low |
| 10 | Write logarithmic law that are used to represent an atmospheric boundary layer. | CO1 | Understand | Medium |

| PART–B | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Discuss the effect of terrain on mean velocity and turbulent intensity profiles of the atmospheric boundary layer. | CO1 | Understand | Medium |
| 2 | Explain the methodology by which the atmospheric boundary layer is simulated in a wind tunnel with necessary sketches. | CO1 | Understand | Medium |
| 3 | Discuss the global and local atmospheric circulations in detail. | CO1 | Understand | Medium |
| 4 | Explain the evaluation of atmospheric boundary layer over the course of a day. | CO1 | Understand | Medium |
| 5 | Briefly explain structure of planetary boundary layer. | CO1 | Understand | Medium |
| 6 | Explain with neat sketches of wind classifications. | CO1 | Understand | Medium |
| 7 | Explain the different types of winds. | CO1 | Understand | Medium |
| 8 | Explain the causes of variation in winds. | CO1 | Understand | Medium |
| 9 | Explain about atmospheric boundary layer. | CO1 | Understand | Medium |
| 10 | Explain the effect of terrain in gradient height. | CO1 | Understand | Medium |

## UNIT – II

## WIND ENERGY COLLECTORS

| PART–A | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | What are the advantages and disadvantages of vertical axis wind turbines? | CO2 | Understand | Low |
| 2 | Define Power coefficient of wind turbines. | CO2 | Remember | Low |
| 3 | Define wind energy. | CO2 | Remember | Low |
| 4 | What is wind mill? | CO2 | Understand | Low |
| 5 | What is wind turbine? | CO2 | Understand | Low |
| 6 | Define wind farm. | CO2 | Remember | Low |
| 7 | Define anemometer. | CO2 | Remember | Low |
| 8 | Define torque coefficient. | CO2 | Remember | Low |
| 9 | Define tip speed ratio. | CO2 | Remember | Low |
| 10 | Define solidity ratio of wind turbine. | CO2 | Remember | Low |

| PART–B | | | | |
|---|---|---|---|---|
| **Q.No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | By applying momentum theory, obtain the maximum power coefficient that can be obtained from ideal wind turbine. | CO2 | Create | High |
| 2 | Describe the aerodynamic power control of wind turbine. | CO2 | Understand | Medium |
| 3 | Discuss the various methods of aerodynamic power control in a wind turbine? | CO2 | Understand | Medium |
| 4 | Discuss the major component of horizontal axis wind turbine. | CO2 | Understand | Medium |
| 5 | Explain about vertical axis wind turbines. | CO2 | Understand | Medium |
| 6 | Explain about power coefficient by momentum theory. | CO2 | Understand | Medium |
| 7 | Explain about Betz coefficient by momentum theory. | CO2 | Understand | Medium |
| 8 | Explain the different parts of wind turbine. | CO2 | Understand | Medium |
| 9 | Explain about horizontal axis machines briefly. | CO2 | Understand | Medium |
| 10 | Discuss the major component of vertical axis wind turbine. | CO2 | Understand | Medium |

# UNIT – III

# VEHICLE AERODYNAMICS

| PART–A | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Write a short note on the power requirement of an automobile. | CO3 | Understand | Medium |
| 2 | Write the role of aerodynamics in design of trucks. | CO3 | Understand | Medium |
| 3 | Why is down force important in racing car? | CO3 | Understand | Low |
| 4 | How is the drag coefficient of car affected by the windshield inclination? | CO3 | Understand | Medium |
| 5 | Define ground vehicle aerodynamics. | CO3 | Remember | Low |
| 6 | Define aerodynamic resistance. | CO3 | Remember | Low |
| 7 | Define rolling resistance. | CO3 | Remember | Low |
| 8 | Define grade resistance. | CO3 | Remember | Low |
| 9 | What are Air dams? | CO3 | Understand | Low |
| 10 | What is front spoiler? | CO3 | Understand | Low |

| PART–B | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | What is Ahmed body? Explain its significance. | CO3 | Understand | Medium |
| 2 | Sketch and explain the pressure distribution over a generic car model. Mark the possible regions of flow separation on the car model. | CO3 | Create | High |
| 3 | Discuss the effect of ground clearance. | CO3 | Understand | Medium |
| 4 | Discuss the effect of rear surface on the aerodynamics of a generic car body. | CO3 | Understand | Medium |
| 5 | What role does invisible air play in shaping the speed, stability, and efficiency of ground vehicles? | CO3 | Understand | Medium |
| 6 | llustrate the interaction between a car's body and surrounding airflow, highlighting key aerodynamic forces with labeled diagrams. | CO3 | Analyze | Medium |
| 7 | Demonstrate the influence of cutback angle on aerodynamic performance and flow behavior around a vehicle, using annotated diagrams to show pressure distribution, turbulence, and flow separation. | CO3 | Understand | Medium |
| 8 | Explain the aerodynamics of race car. | CO3 | Understand | Medium |
| 9 | Visualize and explain the aerodynamic forces acting on a high-speed train, using diagrams to illustrate airflow patterns, drag sources, pressure zones, and the impact on energy efficiency and stability | CO3 | Understand | Medium |

## UNIT – IV

## BUILDING AERODYNAMICS

| PART–A | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Write a short note on building ventilation aerodynamics. | CO4 | Understand | Medium |
| 2 | Write a short note on building codes. | CO4 | Understand | Medium |
| 3 | What does the term 'low-rise building' refer to? | CO4 | Remember | Low |
| 4 | Is it possible for the internal air pressure within a building to be negative? Justify. | CO4 | Analyze | Medium |
| 5 | Define low rise buildings. | CO4 | Remember | Low |
| 6 | What is power law? | CO4 | Understand | Low |
| 7 | Define galloping. | CO4 | Remember | Low |
| 8 | Define flutter. | CO4 | Remember | Low |
| 9 | What is ovalling? | CO4 | Understand | Low |
| 10 | Define building ventilation aerodynamics. | CO4 | Remember | Low |

| PART-B | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Analyze the special problems that arise in the construction and management of high-rise buildings, considering factors such as structural integrity, environmental impact, safety regulations, and the integration of advanced technologies. | CO4 | Analyze | High |
| 2 | Explore the various aspects of ventilation systems and architectural aerodynamics, highlighting their pivotal role in building design and their influence on indoor air quality and energy efficiency. | CO4 | Understand | Medium |
| 3 | Discuss in detail the aerodynamic mitigation techniques/modifications for vortex suppression in low-rise buildings. | CO4 | Understand | Medium |
| 4 | Discuss the flow around low-rise buildings. | CO4 | Understand | Medium |
| 5 | Illustrate and explain the pressure distribution on low-rise buildings under wind flow, using diagrams to show windward and leeward zones, roof uplift areas, and flow separation regions. | CO4 | Analyze | Medium |
| 6 | Explain wind force on buildings. | CO4 | Understand | Medium |

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| **7** | Depict and describe the behavior of environmental winds within urban city blocks, using diagrams to illustrate wind channeling, vortices, corner effects, and pedestrian-level wind patterns. | CO4 | Understand | Medium |
| 8 | Explain the key elements of building codes, using diagrams to highlight structural requirements, safety standards, and compliance factors for different types of buildings. | CO4 | Understand | Medium |
| 9 | Draw with neat sketches about building ventilation aerodynamics. | CO4 | Create | High |
| 10 | Describe the effect of roof pitch angle on the wind loads acting on the roof of a building. | CO4 | Understand | Medium |

## UNIT – V

## FLOW INDUCED VIBRATIONS

| PART–A | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | Write short note on vortex induced vibrations. | CO5 | Understand | Medium |
| 2 | Define galloping with an example. | CO5 | Remember | Low |
| 3 | Define stall flutter. | CO5 | Remember | Low |
| 4 | Differentiate between laminar body and bluff body | CO5 | Understand | Medium |
| 5 | How does the Strouhal number influence the frequency of vortex shedding in Vortex induced Vibration? | CO5 | Understand | Medium |
| 6 | What factor determine the lock in phenomenon in vortex induced vibration? | CO5 | Understand | Low |
| 7 | Define Reynolds number. | CO5 | Remember | Low |
| 8 | How does the angle of attack influence the onset of stall flutter aerodynamic structures? | CO5 | Understand | Medium |
| 9 | What are the primary differences between galloping and stall flutter in terms of fluid-structure interaction? | CO5 | Understand | Low |
| 10 | How do aerodynamic damping and structural | CO5 | Understand | Medium |

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| | damping afftect the stability of system experiencing galloping or stall flutter? | | | |

| PART–B | | | | |
|---|---|---|---|---|
| **Q. No** | **Questions** | **CO Mapping** | **BT Level** | **Complexity** |
| 1 | With necessary sketches, discuss the various methods to control the vortex induced vibration of cylinder. | CO5 | Understand | Medium |
| 2 | Explain the effect of Reynolds number on wake formation of a bluff body, explain the various flow regimes involved. | CO5 | Understand | Medium |
| 3 | How does the Reynolds number impact the wake formation in the flow around bluff bodies? Elaborate on this phenomenon with the support of appropriate diagram for better visualization. | CO5 | Understand | Medium |
| 4 | Describe the galloping phenomenon, focusing specifically on conductor galloping with detailed explanation and analysis. | CO5 | Understand | Medium |
| 5 | How do flow-induced vibrations impact the structural integrity of tall buildings and towers? Elaborate it. | CO5 | Understand | Medium |

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|---|---|---|---|---|
| 6 | How does wind-induced vortex shedding affect the performance of transmission lines and cables? Justify briefly. | CO5 | Analyze | High |
| 7 | Describe in detail about the role do aerodynamic modifications (e,g. spoilers, fairings) play in controlling flow induced vibration in industrial structures. | CO5 | Understand | Medium |
| 8 | Discuss the computational fluid dynamics (CFD) simulations used to predict analyze flow induced vibration in industrial applications. | CO5 | Understand | Medium |
| 9 | Elaborate the effect of flow induced vibrations on the fatigue life of large-scale industrial structures, such as bridges and wind turbines. | CO5 | Understand | Medium |

# THANK YOU

# ALL THE BEST