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METR 3133 – Mesoscale Meteorology
Fall 2016

Exam #2 Study Guide

Below are listed the principal topics, concepts, and capabilities for which you will be responsible on the first exam. The absence of a topic from this sheet does NOT imply that it will be absent from the exam!

Vector Operations

1. Know how to take the total derivative of a vector, of a vector times a scalar, of a dot product of two vectors, of a cross product of two vectors, and of the magnitude of a vector.
2. Understand and be able to use the velocity and acceleration vectors in both Cartesian and polar coordinates.
3. Understand and be able to apply the del (nabla) operator as well as the divergence and curl operators.
4. Know the meaning of a total differential.
5. Understand the concept of a directional derivative, be able to apply it in physical situations, and know how it relates to the projection of the gradient of a scalar.
6. Understand the difference between gradient and divergence and be able to use them in Cartesian and polar coordinates.
7. Know how to compute the cross product of two vectors using the determinant.
8. Understand what is meant by invariance with regard to vector operations.
9. Understand the vorticity vector and be able to use its components.
10. Understand physically and mathematically the Laplace operator and Laplacian.
11. Understand and be able to explain the divergence theorem and describe its relevance to meteorology. Note that you need not memorize the theorem but will be provided the equations.
12. Understand the concept of mass continuity and be able to use and explain the mass continuity equation in mass divergence and velocity divergence form (vector and component formulation).
13. Understand the concept of flux and flux divergence, including in the context of the mass continuity equation.
14. Know what is meant by an incompressible fluid.
15. Be able apply vector operators to simple 2D flow fields and determine their properties (e.g., divergent, rotational, deformational) using both Cartesian and polar coordinates.

Reference Frames, Newton's Laws and Real Forces

1. Know the difference between inertial and non-inertial reference frames and be able to give examples of each.
2. Know and be able to explain Newton's first and second laws of motion.
3. Understand the difference between body forces and surface forces and be able to give examples of each.

4. Understand physically and mathematically the pressure gradient force (per unit mass) in both vector and component form, and be able to use it.
5. Understand and be able to apply Newton's law of gravity (you will not need to memorize the equation).
6. Understand the concept of viscosity and shearing stress.
7. Be able to explain normal and tangential shearing stresses in a fluid.
8. Know how normal shearing stresses relate to pressure.
9. Understand and be able to apply the concept of viscous force and the kinematic viscosity.
10. Understand the analog between molecular and eddy viscosity.

Apparent Forces

1. Understand the concept of an apparent force and how it relates the nature of the reference frame (inertial, non-inertial).
2. Understand the nature of the centripetal force/acceleration and be able to utilize it in both Cartesian and polar coordinates. You will be given equations as necessary.
3. Understand the nature of the centrifugal force/acceleration and how it relates to the centripetal force/acceleration.
4. Understand how the centrifugal force and gravitational force are combined to yield the effective acceleration due to gravity.
5. Be able to show and explain the difference between effective gravity (including centrifugal force) and the standard gravitational force.
6. Be able to define the geopotential and utilize it.
7. Know the meaning of a conservative force and how it relates to a potential function.
8. Be able to explain the value of using a potential function instead of the corresponding vector function.
9. Understand and be able to explain the origin of zonal deflecting forces owing to the rotation of Earth and conservation of angular momentum.
10. Understand what is meant by curvature terms in the equations of motion.
11. Understand and be able to explain the origin of radial deflecting forces owing to the rotation of Earth and the centrifugal force.
12. Understand all components of the Coriolis force.
13. Understand and be able to use the Coriolis parameter (you DO need to memorize it).
14. Be able to solve problems involving accelerations and deflections associated with the Coriolis force. You will not have to memorize the Coriolis equations.
15. Be able to explain the Coriolis force expressed in 2D and 3D vector form (you do not need to memorize the associated expressions).
16. Understand and be able to explain situations in which the Coriolis force is or is not important.
17. Understand and be able to explain the concept of inertial oscillations (you do not need to memorize the associated equations).
18. Know how to compute the period of an inertial oscillation and give physical examples of them.