# Open Yale courses

Answers to the second exam.

1. [10] A top view of a Foucault Pendulum base plate is shown with the track of the bob as it swings across. Sketch forces on the bob and explain how the track will rotate if the pendulum is in the southern hemisphere.

As the bob moves northward, it feels the Coriolis Force deflecting it to the left (west). As it moves back to the south, the bob is deflected to the left (east). These forces rotate the plane of the bob counter-clockwise.
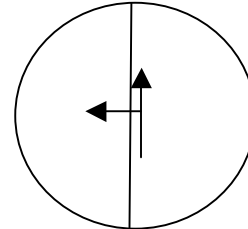
2. [10] Explain how cool winds and a gustfront are created by a thunderstorm.

As rain falls out of the bottom of the cloud, the drops are partially evaporated causing a cooling of the air. This cool dense air flows downward to the ground and spreads out as a gustfront.

3. [10] If at 45 degrees north latitude, the horizontal pressure gradient is 0.002Pa/m with pressure increasing towards the west:
   a. **Estimate** wind speed above the turbulent boundary layer.

   For this we use the geostrophic balance assumption
   $$U = PG/(2\rho\Omega\sin(\phi)) = (0.002)/(2(1.2)(7.25\times10^{-5})(.71))$$
   $$= 16.2 m/s$$

   b. **Give** the wind direction. (include a **sketch** showing forces)

   If pressure increases towards the west, the geostrophic wind will blow towards the south.

   c. **Explain** the force balance you have assumed to do this problem.

   The geostrophic balance is a balance between the pressure gradient force and the Coriolis Force.

4. [10] Explain why the clear sky appears blue but a cloud appears white under similar illumination from the sun.

The type of scattering depends on the size of the particles doing the scattering. The air molecules are smaller than the wavelength of visible light so the scattering falls into the Rayleigh regime. The shorter wavelengths (blue) are scattered more intensely than the longer wavelengths (Red). This, the sky appears blue.

The cloud particles are larger (about 10 microns) and cause Mie scattering where all wavelengths a re scattered equally. As the sun's radiation has equal amount of RGB, and appears white; so does the light scattered from the cloud.

5. [10] Why are hurricanes not found over the sea
   a. Near the equator

   Near the equator, the Coriolis Force is too weak to give rotation to a hurricane. It cannot exist without the stabilization and organization provided by its rotation.

   b. In the tropical south Atlantic

   There is a region in the tropical South Atlantic where hurricanes might form if the SST were warmer. The cold Benguela current keeps it too cold there.

6. [10] Explain why water drops may form on the outside of a cool glass of water. What condition is required?

   Droplets will form on the outside of the glass if the glass temperature is less than the dewpoint of the surrounding air. As air near the glass cools by contact, its saturation vapor pressure decreases until excess vapor condenses.

7. [10] Describe how the raindrops form that fall from a tall cumulo-nimbus cloud.

   The ice-phase (or Bergeron) process dominates in these clouds. In this mechanism, a few droplets freeze and draw vapor from the other droplets as a snowflakes grow. As the snow falls to earth, it melts to form raindrops.

8. [10] If a mid-latitude cyclone in the northern hemisphere transports $10^{11}kg/s$ of air northward with T=20C and an equal mass of air moves southward with T=10C, **how much heat** is transported northward? Express your answer in Watts. **What happens** to this heat transported northward?

*The heat transported by moving air is the mass transport times the heat per unit mass (Cp * T). As the same water mass is moving northward and southward, the net heat transport is*

$$Net\ Heat = (mass\ rate)(Cp)(\Delta T) = (\frac{10^{11}kg}{s})(1004)(10) = 1.004 \times 10^{15}\,W$$

9. [10] On a rainy day, a centimeter of rain falls on a 10000 square kilometer area (i.e. 100 by 100km). **Estimate the latent heat** released to the atmosphere in the clouds causing that precipitation. Express your answer in Joules.

The volume of water that falls to earth is $(10^{10}m2)(0.01m) = 10^8 m3$
The mass of that water is $V \times \rho = 10^{11}kg$

The heat released is computed from the latent heat of condensation

$$Q = (10^{11}kg)\left(2.5 \times \frac{10^6 J}{kg}\right) = 2.5 \times 10^{17} J$$

10. [10] **Explain** the reason for the rainy season at each location below.

   a. **Jerusalem** ,Israel/Jordan/Palestine (Lat =32N, Long = 35E) The wettest month is January (P = 5.1 inches; temperature of T = 44F). The driest month is July (P=0; T=73F).

   Winter is the wet season, caused by frontal cyclones shifting southward. The storms arise from the pole to equator differential heating from the sun.

   b. **Asuncion, Paraguay** (25S, 58W) The wettest month is December (P=6.2 inches, T=80F). The driest month is July (P=2.2 inches, T=64F)

   This is a summer wet season in the southern hemisphere. The ITCZ shifts southward bringing convective rain. Southern hemisphere tilts towards the sun in this season.