EAS 475/587: Atmospheric and Ocean Dynamics

Assignment 3: Due in class Thursday, Nov. 23 at 2pm.

1. For the following surface (gravity) waves, find their phase and group speed and the speed of the water at the crest of the wave. (Give your answer in units of m/s.)

   (a) A 0.1 cm amplitude wave in a tank filled 10 cm deep with water having wavelength 6 cm.

   (b) A 1 cm amplitude wave in a tank filled 10 cm deep with water having wavelength 60 cm.

   (c) A 1 cm amplitude wave in a tank filled 10 cm deep with water having wavelength 600 cm.

2. As a surfer waits to "catch" a wave, waves of 20 cm amplitude and wavelength 20 m pass toward shore underneath. Assuming the water is deep compared to the wavelength, what is the speed at which the surfer drifts toward shore? (Give your answer in units of m/s.)

3. On March 11, 2011 a devastating tidal wave was launched by an earthquake off the coast of Sendai in north-eastern Japan (38°N, 140°E). The same earthquake launched an inertial wave that propagated outward in the Pacific ocean. Eventually this resulted in a small tidal wave in Honolulu (21°N, 157°W) and beyond. In the problem below, assume that the wave propagated approximately due east a distance of 6.2×10^3 km over a uniform-density ocean with $\rho = 10^3$ kg/m^3 and which has a uniform depth of $H = 4$ km on the f-plane with $f_0 \simeq 10^{-4}\,\mathrm{s}^{-1}$.

   (a) In the mid-ocean, the disturbance had a horizontal wavelength of about 200 km. Determine the group velocity of the wave and so estimate the time it took to travel from Sendai to Honolulu.

   (b) The amplitude of the wave in the open ocean was about 2 cm. What were the corresponding amplitude magnitudes of the zonal and meridional velocities?

   (c) Estimate the average power over one wavelength delivered in the direction of motion across an along-crest distance of 1 km. (Your answer should be in Watts.)

4. For the following bodies of water, determine the deformation radius (in km) and so estimate the critical wavelength of inertial waves that lies between those strongly influenced by rotation and those not influenced by rotation. (Explicitly calculate the Coriolis parameter, f_0, in these problems.)

   (a) Lesser Slave Lake, with a mean depth of 11 m situated at 55°N.

   (b) Hudson's Bay, with a mean depth of 100 m situated around 60°N.

5. A 200 km wavelength coastal Kelvin wave in a 4 km deep ocean moves northward past San Diego, which is situated at 33°N. Its amplitude (maximum vertical surface displacement) near the coast is 10 cm.

   (a) What are the maximum zonal and meridional velocities near the coast?

   (b) What is the maximum vertical surface displacement 1000 km west of the coast?