ball upon the
f the ball. [**Hint**:
the downward
face with each
erval between
result suggest
an atmosphere

mass of the
stratosphere based
he mean pressure
round 100 hPa
popause is near
e tropical and the
s near 30° latitude
he Earth lies in
trop On the

level up to the 850-hPa pressure surface. Estimate the equatorward mass flux into the equatorial zone. [**Hint**: The equatorward mass flux across the 15 °N, in units of kg s^{-1}, is given by

$$-\oint_{15\,°\mathrm{N}} \int_0^{z850} \rho v\, dz\, dx$$

mass flux

units: $\left(\frac{kg}{m^3}\right)\frac{m}{s} = \frac{kg \leftarrow stuff}{m^2 s} = mass$

where ρ is the density of the air, v is the meridional (northward) velocity component, the line integral denotes an integration around the 15 °N latitude circle, and the vertical integral is from sea level up to the height of the 850-hPa surface. Evaluate the integral, making use of the relations

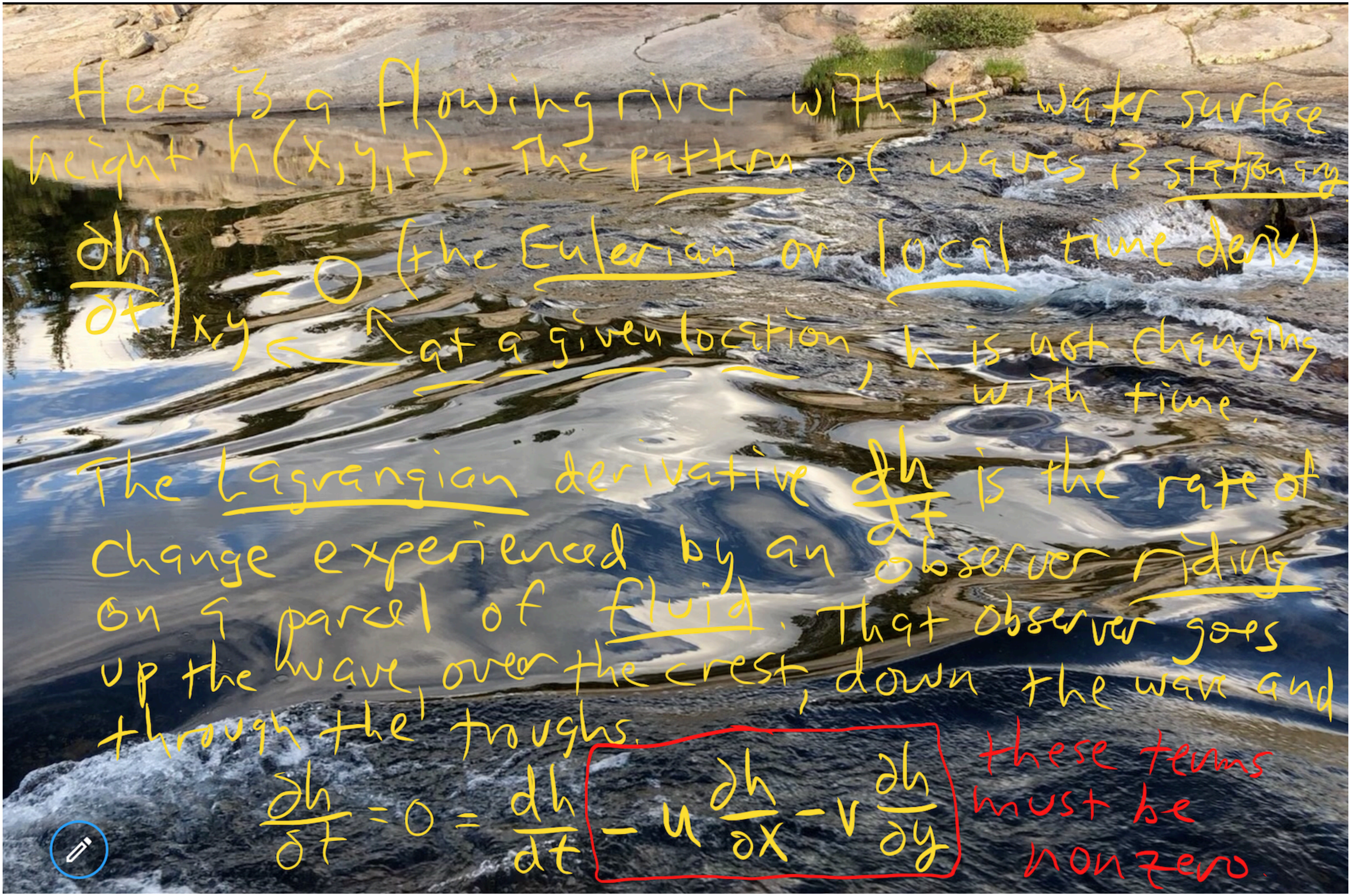
$$\oint_{15\,°\mathrm{N}} dx = 2\pi R_E \cos 15°$$

What is a flux?
units contain the meaning.

what units are a momentum flux?

$\left(\frac{kg\, m/s}{m^2 \cdot s}\right)$

units of force $F = ma$
$\left(kg \frac{m}{s^2}\right)$



Here is a flowing river with its water surface height $h(x,y,t)$. The pattern of waves is stationary

$\left.\frac{\partial h}{\partial t}\right)_{x,y} = 0$ (the Eulerian or local time deriv.)

$\uparrow$ at a given location, h is not changing with time.

The Lagrangian derivative $\frac{dh}{dt}$ is the rate of change experienced by an observer riding on a parcel of fluid. That observer goes up the wave, over the crest, down the wave and through the troughs.

$$\frac{\partial h}{\partial t} = 0 = \frac{dh}{dt} \boxed{- u\frac{\partial h}{\partial x} - v\frac{\partial h}{\partial y}}$$

these terms must be nonzero.