1. **Ocean heat transport** *(5 points)*

   Calculate the ocean heat transport in the numerical ocean model and compare it with the following estimate!

$$
\begin{aligned}
H &= \int_{bottom}^{top} \rho_0 v T dz && (1)\\
&= -c_p \int_{bottom}^{top} \frac{\partial \Phi}{\partial z} \quad T dz && (2)\\
&= c_p \int_{bottom}^{top} \Phi \quad \frac{\partial T}{\partial z} dz && (3)\\
&= c_p \int_{T(bottom)}^{T(top)} \quad \Phi dT && (4)
\end{aligned}
$$

   where $\Phi = \rho_0 \Phi_{MOC}$ with Φ_{MOC} being the volume transport. Therefore, the heat transport can be estimated in terms of the mass transport in temperature layers:

$$H = c_p \underbrace{(T(top) - T(bottom))}_{15K} \quad \underbrace{\Phi_{max}}_{20 \cdot 10^9 kg/s} \qquad (5)$$

   which is about 1.2 $PW (PW = 10^{15} W)$.

2. **Short programming questions.** *(5 points)*

   Write down the output for the following R-commands:

   a) `a<-c(0,-5,4,20); mean(a)`

   b) `max(a)-min(a)`

   c) `a*2+c(3,1,-1,0)`

   d)
```
my.fun<-function(n){return(n*n+n-1)}
my.fun(6)-my.fun(1)
```

Notes on submission form of the exercises: *Working in study groups is encouraged, but each student is responsible for his/her own solution. The answers to the questions can be send until the due date (12:00) to Hanna Knahl (hanna.knahl@awi.de), Alexander Thorneloe (alexander.thorn@awi.de).*