

50 shades of grey



it's been a journey!



# THE GRAND CHALLENGE EQUATIONS

$$B_i A_i = E_i A_i + \rho_i \sum_j B_j A_j F_{ji} \quad \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \quad \vec{F} = m \vec{a} + \frac{dm}{dt} \vec{v}$$

$$dU = \left(\frac{\partial U}{\partial S}\right)_V dS + \left(\frac{\partial U}{\partial V}\right)_S dV \quad \nabla \cdot \vec{D} = \rho \quad Z = \sum_j g_j e^{-E_j/kT}$$

$$F_j = \sum_{k=0}^{N-1} f_k e^{2\pi i j k / N} \quad \nabla^2 u = \frac{\partial u}{\partial t} \quad \nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$$

$$p_{n+1} = r p_n (1 - p_n) \quad \nabla \cdot \vec{B} = 0 \quad P(t) = \frac{\sum_i W_i B_i(t) P_i}{\sum_i W_i B_i(t)}$$

$$-\frac{\hbar^2}{8\pi^2 m} \nabla^2 \Psi(r, t) + V \Psi(r, t) = -\frac{\hbar}{2\pi i} \frac{\partial \Psi(r, t)}{\partial t} \quad -\nabla^2 u + \lambda u = f$$

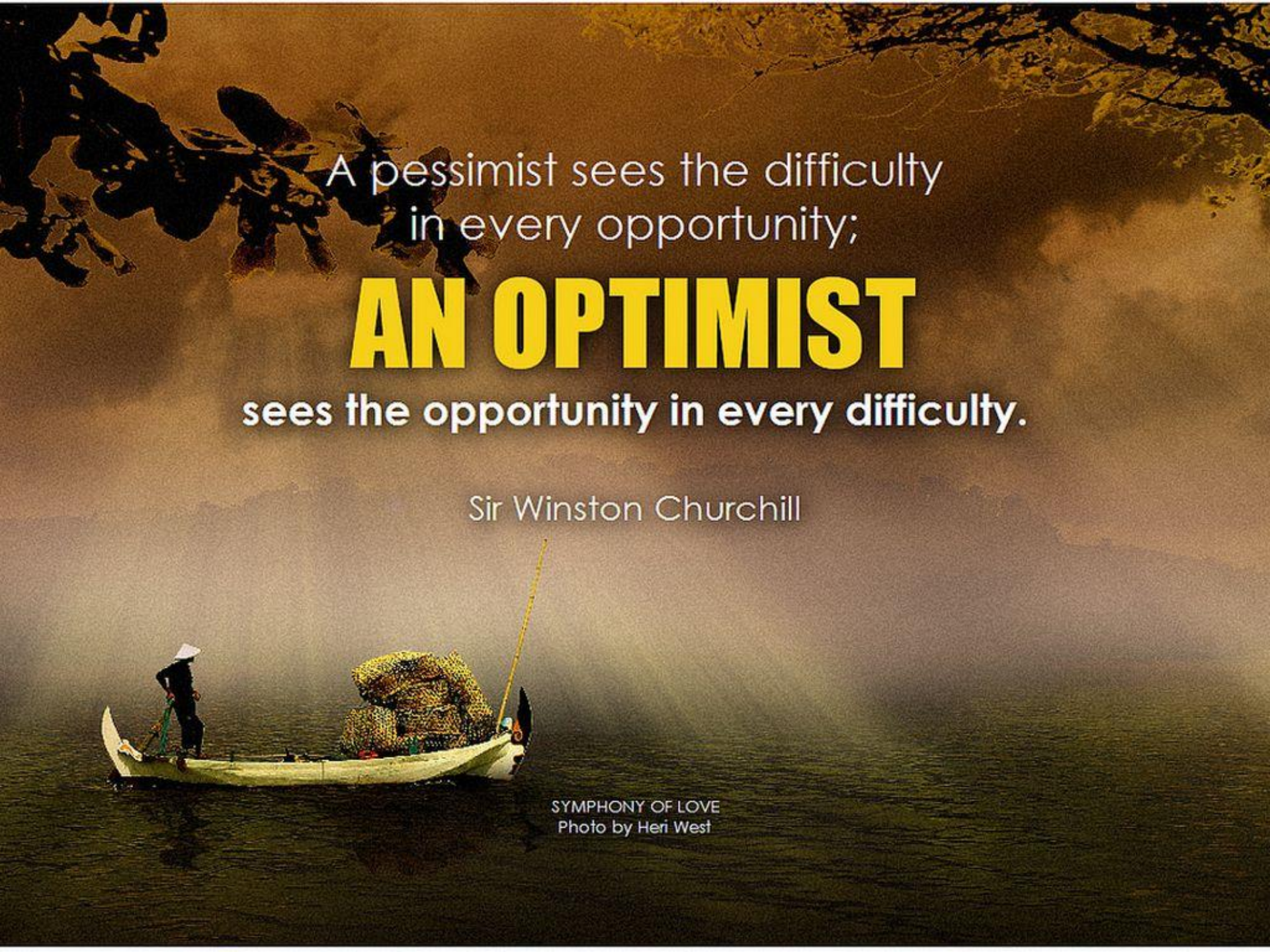
$$\frac{\partial \vec{u}}{\partial t} + (\vec{u} \cdot \nabla) \vec{u} = -\frac{1}{\rho} \nabla p + \gamma \nabla^2 \vec{u} + \frac{1}{\rho} \vec{F} \quad \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = f$$

- NEWTON'S EQUATIONS • SCHRÖDINGER EQUATION (TIME DEPENDENT) • NAVIER-STOKES EQUATION •
- POISSON EQUATION • HEAT EQUATION • HELMHOLTZ EQUATION • DISCRETE FOURIER TRANSFORM •
- MAXWELL EQUATIONS • PARTITION FUNCTION • POPULATION DYNAMICS •
- COMBINED AND 21 LAWS OF THERMODYNAMICS • RADIATION • SPLITTING

SAN DIEGO SUPERCOMPUTER CENTER  
 National Laboratory for Computational Science and Engineering

# challenges



A photograph of a person in a small boat on a misty lake. The person is wearing a white conical hat and is standing in the boat, which is filled with a large stack of goods, possibly fish or produce. The background is a hazy, misty landscape with trees and water. The overall tone is somber and atmospheric.

A pessimist sees the difficulty  
in every opportunity;

**AN OPTIMIST**

sees the opportunity in every difficulty.

Sir Winston Churchill

SYMPHONY OF LOVE  
Photo by Heri West





keys to success