FORMULA SHEET

General formulas:

Newton's 2nd law of motion. $F = m * a$

Kinetic energy. $E_k = \frac{1}{2}mv^2$

Gravitational energy. $E_g = m * g * h$

Angular velocity of circular motion, where T is the period of the motion . $\omega = \frac{2\pi}{T}$

Ideal gas law. R is the Gas constant $pV = nRT$

Density in mass per unit volume. $\rho = \frac{m}{V}$

Specific heat: Heat needed to heat an object by 1 degree Celsius. Units are $\frac{J}{kg*K}$. $C = \frac{Q}{m\Delta T}$

The conversion of going from Celsius to Kelvin. It is important to note that negative temperatures do not exist on the Kelvin scale, while they do for the Celsius scale, so when calculating with absolute temperatures, use Kelvin. In relative calculations where you take a temperature difference, it doesn't matter since Kelvin and Celsius are the same scale, except they are shifted. $T_K = T_{°C} + 273,15$

The radius of a circle, where r is the radius (half the diameter) of the circle. $s = 2\pi r$

The area of a circle. $A = \pi r^2$

The volume of a sphere. $V = \frac{4}{3}\pi r^3$

Constants

$N = 6.022 * 10^{23}$ The number of molecules in a mole, called Avogadro's Constant.

$R = 8.315 \frac{J}{mol*K}$. The gas constant

Quantities &Units

Mass	m	kg
Time	t	s
Volume	V	m^3
Velocity	v	m/s
Density	ρ	$kg.m^{-3}$
Force	F	N
Temperature	T	K
Pressure	p or P	Pa
Flow	ϕ	$kg.m^{-2}s^{-1}$
Diffusion coefficient or diameter	D	
Internal energy	U	
Heat	Q	
Work	W	Nm
Total energy	E	J
Area	A	m^2
Heat transfer coefficient	h	
Thermal conductivity	λ	
Specific heat	C_p	
Drag coefficient	C_D	
Thermal diffusivity	a	
Viscosity	η	
Fourier's number	Fo	
Mass transfer coefficient	k	

WEEK 1:

The general balance equation.	$\frac{d}{dt} = in - out + production$

WEEK 2:

Total energy balance	$\frac{dE}{dt} = \phi_{m,in} * \left\{U + \frac{p}{\rho} + \frac{1}{2}v^2 + gh\right\}_{in} - \phi_{m,out} * \left\{U + \frac{p}{\rho} + \frac{1}{2}v^2 + gh\right\}_{out}$
First law of Thermodynamics, where ΔW is the net work done on the system.	$\Delta U = \Delta Q + \Delta W$
The thermal energy balance in a steady state without energy change.	$0 = \phi_m(u_{in} - u_{out}) + \phi_q + \phi_m e_{fr}$
The mechanical energy balance.	$0 = \phi_m\left(\frac{(v_{in}^2 - v_{out}^2)}{2} + g(h_{in} - h_{out}) + \frac{(p_{in} - p_{out})}{\rho} + \phi_w - \phi_m E_{fr}\right)$
Bernoulli's equation: Neglects all friction and heat production. h is height.	$\frac{p}{\rho} + \frac{v^2}{2} + gh = constant$
Bernoulli's Principle: The energy per unit volume before is the same as the energy per unit volume after.	$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

WEEK 3:

Reynolds number, where ρ_f is the density of the fluid, v_r is the relative velocity, D is the diameter and μ is the viscosity of the fluid	$Re = \frac{\rho_f v_r D}{\mu}$
The drag force. C_D is the drag coefficient, A is the frontal area, v is the relative velocity.	$F_D = C_D A * \frac{1}{2}\rho_f v_r^2$
Stokes' law: The drag force on a sphere with a low Reynolds number ($Re < 1$).	$F_D = 3\pi D \mu v_r$

WEEK 4:

Fourier's law, the transfer of heat. λ is the material conductivity, Δx is the thickness, A is the area, ΔT is the difference in temperature.	$\phi_q = \lambda A * \frac{\Delta T}{\Delta x}$
Fick's law of diffusion, analogous to Fourier's law. D is the diffusion coefficient, A is the area and $\frac{dC_a}{dx}$ is the change in concentration over x.	$\phi_m = -D * A * \left(\frac{dc_A}{dx}\right)$

WEEK 5:

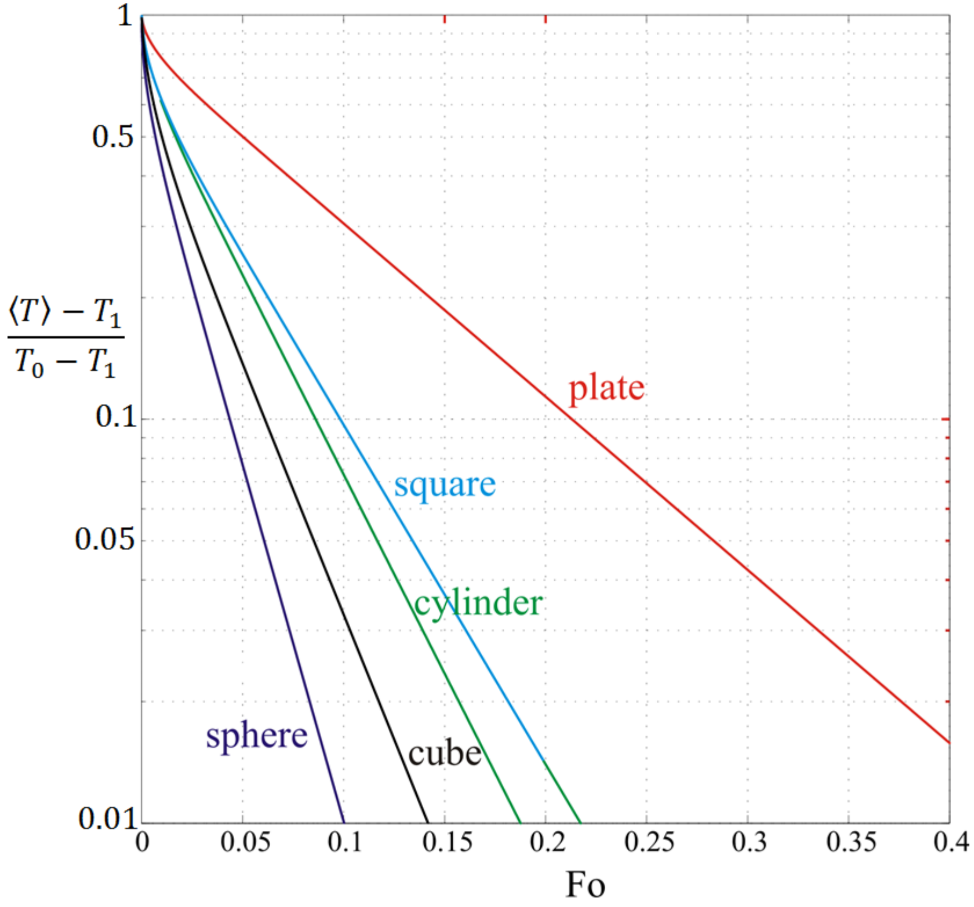
Newton's law of cooling. h is the heat transfer coefficient.	$\phi_q = h \cdot A \cdot \Delta T$
Nusselt number. Used to make h dimensionless.	$Nu = \frac{D \cdot h}{\lambda}$
Mass transfer coefficient, where Sh is the Sherwood number, analogous to Nusselt number. Δx is the size of the object, also called D sometimes.	$k = Sh \cdot \frac{\mathrm{D}}{\Delta x}$

WEEK 6:

Thermal diffusivity. λ is thermal conductivity, ρ is material density, C_p is specific heat.	$a = \frac{\lambda}{\rho \cdot C_p}$
Penetration depth. Only valid while penetration theory still holds, for $\sqrt{\pi a t} < \frac{D}{2}$, where D is the size of the sheet being penetrated by heat.	$x_p = \sqrt{\pi a t}$
Fourier number.	$Fo = \frac{at}{D^2}$
Nusselt number for penetration theory.	$Nu = \sqrt{\frac{1}{\pi Fo}}$

WEEK 7: No new formulas this week! ☺

GRAPHS:



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$\frac{\langle T\rangle - T_1}{T_0 - T_1}$
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0.05
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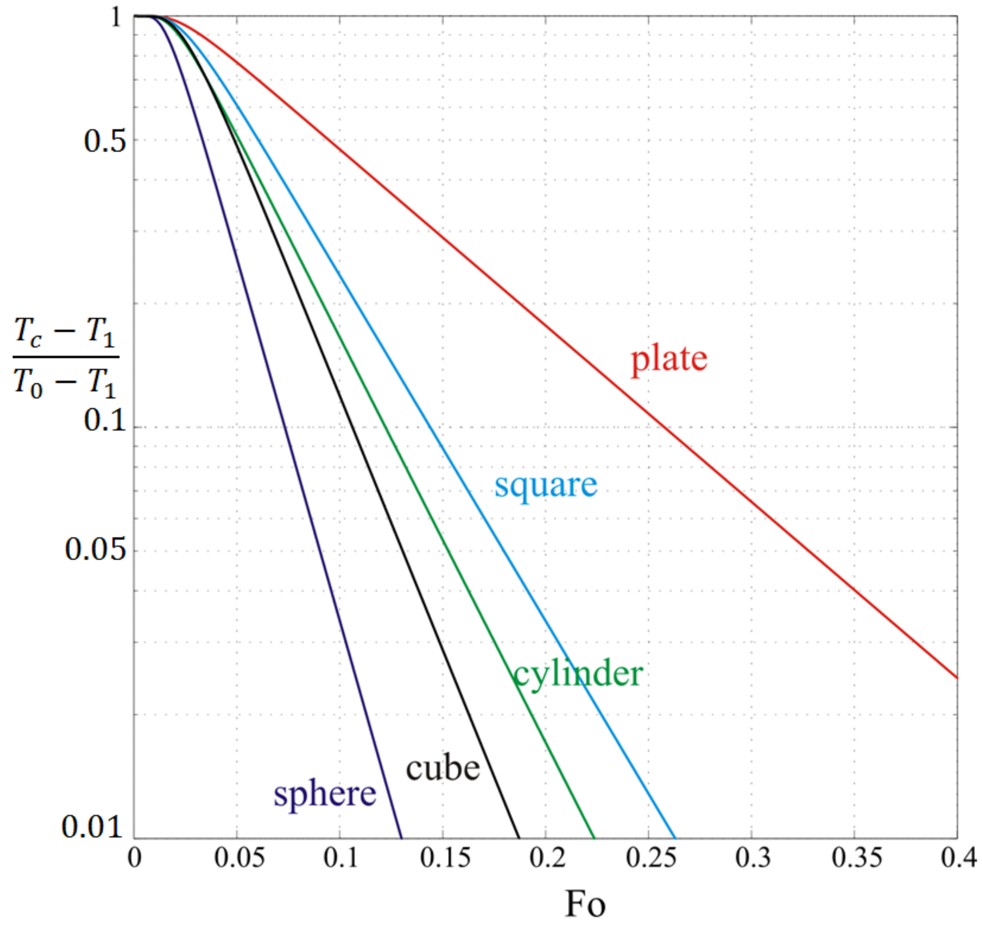
0.35
0.4
Fo
plate
square
cylinder
sphere
cube



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$\frac{T_c - T_1}{T_0 - T_1}$
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Fo
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cylinder
cube
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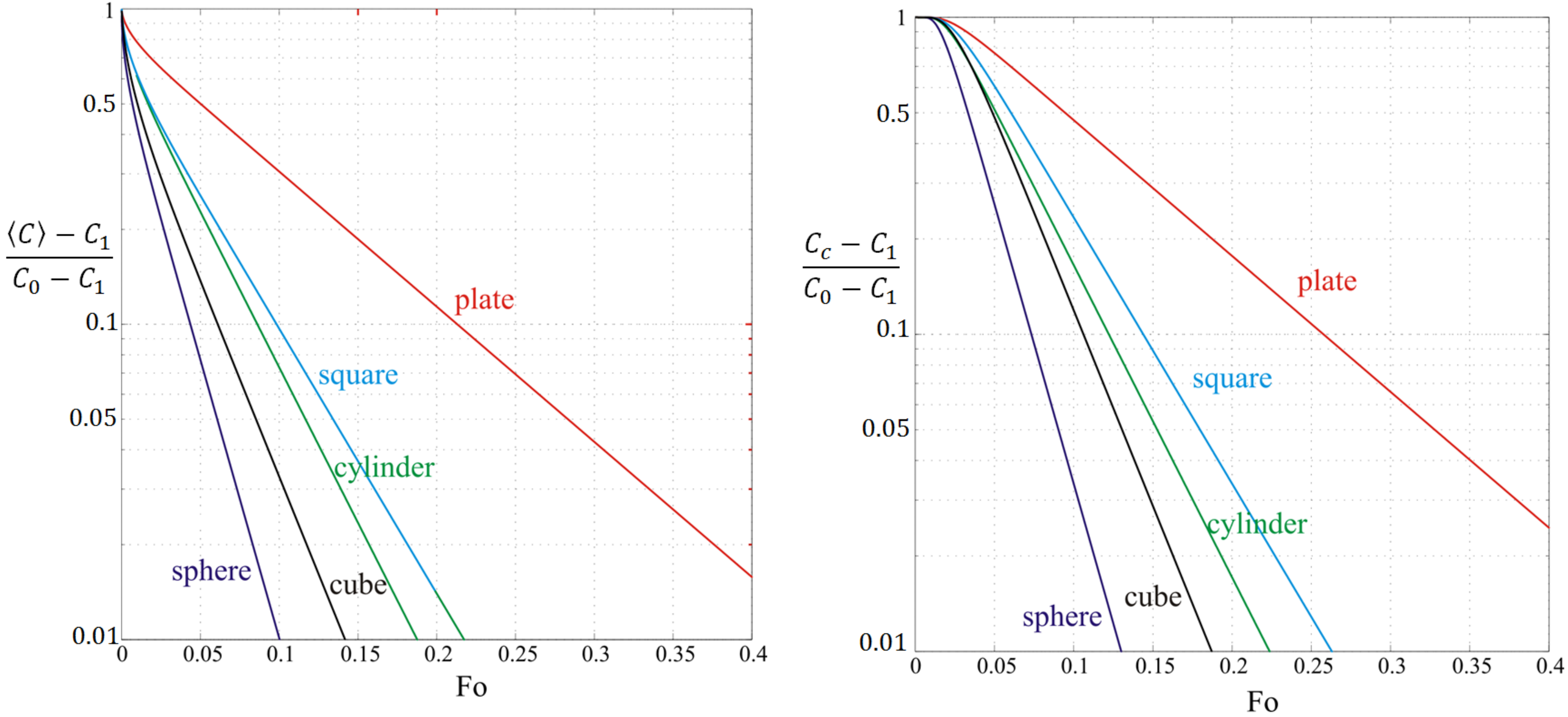

$\frac{\langle C \rangle - C_1}{C_0 - C_1}$
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0.05
0.01
plate
square
cylinder
cube
sphere
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0.05
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0.15
0.2
0.25
0.3
0.35
0.4
Fo
$\frac{C_c - C_1}{C_0 - C_1}$
1
0.5
0.1
0.05
0.01
plate
square
cylinder
cube
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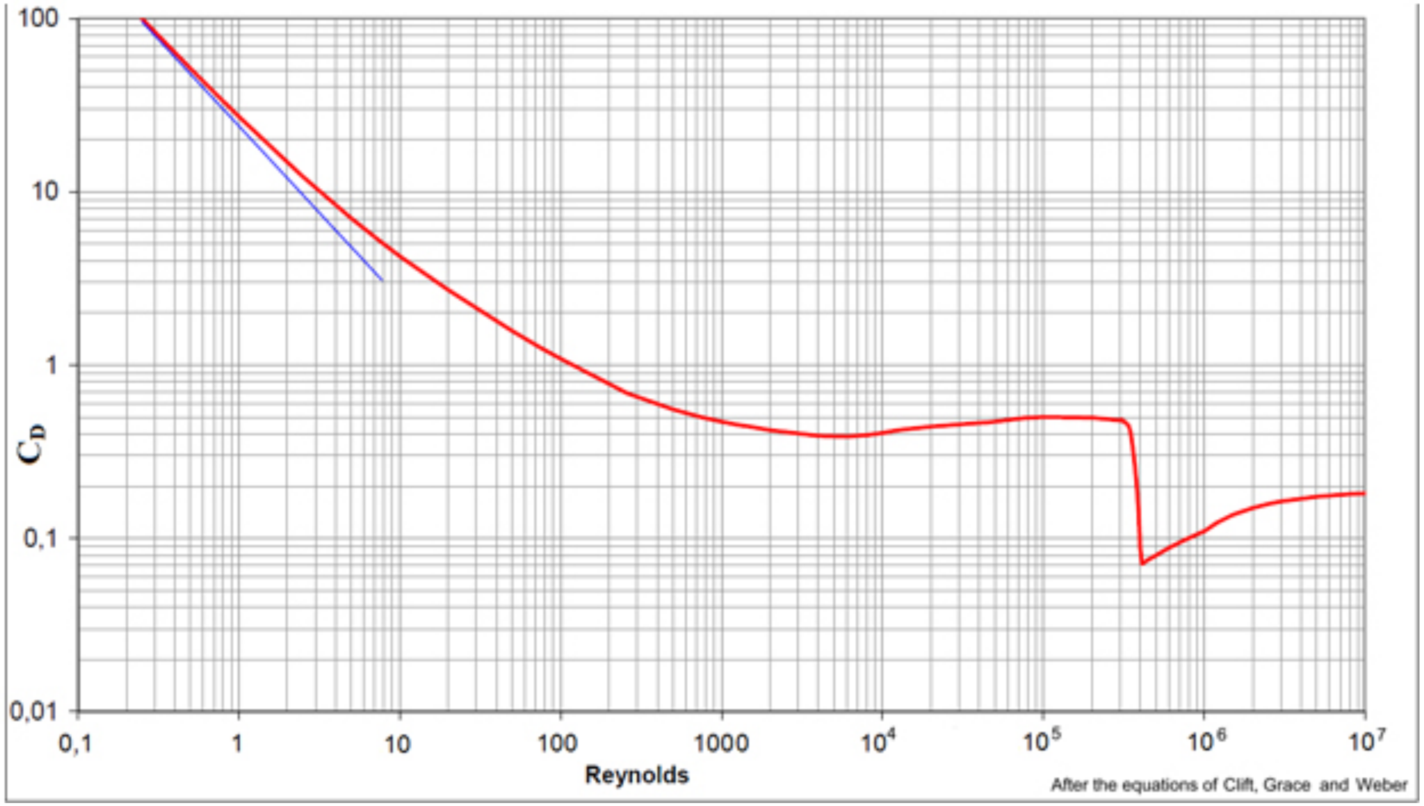
FOR A SPHERE


100
10
1
0,1
0,01
C_D
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10
100
1000
10^4
10^5
10^6
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Reynolds
After the equations of Clift, Grace and Weber