Menoufiya University **Faculty of Engineering** **Shebin El-Kom** **Second Semester Examination** **Academic Year: 2013-2014**	Minufiya University	**Year: Post Graduate** **Department: Hydraulics** **Subject: Non-Newtonian Fluids** **Time Allowed: 3 hours** **Date: 17.06.2014**

Allowed Tables and Charts: None

Answer all the following Questions **[100 Marks for all]**

Question (1) *(50 Marks)*

(a) What are the main classifications of fluid behavior? Show different examples of Non-Newtonian fluids and plot the main flow curves indicating the various types of time-dependent fluids. *(10 Marks)*

(b) Derive the velocity profile and the volume flow rate and walls shear stress of Bingham plastics-flow between two parallel plates for the following conditions:
(I) Fixed plates *(15 Marks)*
(II) Moving the upper plate with velocity U_w and fixing the lower one *(15 Marks)*

(c) For Bingham plastics flow in a circular pipe, derive the Buckingham's equation and how to reduce it to Newtonian fluids. *(10 Marks)*

Question (2) *(50 Marks)*

(a) Develop expressions for the boundary layer thickness δ, the wall shear stress τ_w, the total frictional drag force F_{df} and the drag coefficient C_{df} for laminar boundary layer flow of power law fluids over a flat plate with zero pressure gradient flow, assuming the velocity profile in the boundary layer to be given by:

$$\frac{u}{U_\infty} = A + B\left(\frac{y}{\delta}\right) - C\left(\frac{y}{\delta}\right)^3$$ *(25 Marks)*

(b) Compare the previous results obtained in (a) if the velocity profile is expressed as:

$$\frac{u}{U_\infty} = C\sin\left(D\frac{y}{\delta}\right)$$ *(25 Marks)*

Best wishes
Assoc. Prof. Dr. Eng. Wageeh El-Askary

The following relations may be used:

x-Momentum:

$$\rho\left[\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right] = -\frac{\partial p}{\partial x} - \left(\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z}\right) + \rho g_x$$

z-Momentum (cylindrical coordinates)

$$\rho\left[\frac{\partial v_z}{\partial t} + v_r\frac{\partial v_z}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta} + v_z\frac{\partial v_z}{\partial z}\right] = -\frac{\partial p}{\partial z} - \left(\frac{1}{r}\frac{\partial r\tau_{rz}}{\partial r} + \frac{1}{r}\frac{\partial \tau_{\theta z}}{\partial \theta} + \frac{\partial \tau_{zz}}{\partial z}\right) + \rho g_z$$