TEACHING GUIDE ON

NANOSTRUCTURED FLUIDS. RHEOLOGICAL PROPERTIES

<table>
<tr><th>MASTER MODULE</th><th>SEMESTER</th><th>CREDITS</th><th>COURSE TYPE</th></tr>
<tr><td>NANOTECHNOLOGY: PHYSICS AND APPLICATIONS</td><td>2</td><td>6</td><td>Optative</td></tr>
<tr><td colspan="2">PROFESSOR(S)</td><td colspan="2">CONTACT DETAILS</td></tr>
<tr><td colspan="2" rowspan="2">Juan de Dios García López-Durán (JD)- Chapter II. Two credits
Juan de Vicente Álvarez-Manzaneda (JV)- Chapters I and III. Three credits
Modesto López López (ML)- Chapter IV. One credit</td><td colspan="2">Dept. Applied Physics, 1st floor, Physics Building, School of Sciences. Offices: 13 (JD); 11 (JV); 7 (ML)
e-mails: Correos electrónicos: jdgarcia@ugr.es; jvicente@ugr.es; modesto@ugr.es</td></tr>
<tr><td colspan="2">TUTORIALS TIMETABLE</td></tr>
<tr><td colspan="2"></td><td colspan="2">Links:
JD – https://directorio.ugr.es/static/PersonalUGR/*/show/0ffce78e3e819aaf8c0135dbaaa60572
JV - https://directorio.ugr.es/static/PersonalUGR/*/show/ba8ca192141c34be1ec225a022ce9424
ML - https://directorio.ugr.es/static/PersonalUGR/*/show/d58e6e8fd015f8c6e1e06456fd306039</td></tr>
<tr><td colspan="4">MASTER DEGREE</td></tr>
<tr><td colspan="4">University Master in Physics: Radiations, Nanotechnology, Particles and Astrophysics, University of Granada</td></tr>
<tr><td colspan="4">TEACHING DATES AND TIMES</td></tr>
<tr><td colspan="4">Second Semester. Start: February 2017. PROVISIONAL TEACHING TIME: Tuesday (12:00-13:00); Wedneday (11:00-13:00)</td></tr>
<tr><td colspan="4">PRE-REQUISITES FOR REGISTRATION</td></tr>
<tr><td colspan="4">Only those required for Master access.</td></tr>
<tr><td colspan="4">BRIEF CONTENTS DESCRIPTION</td></tr>
<tr><td colspan="4">Constitutive equations of newtonian fluids. Viscoelasticity. Experimental methods in Rheology. Rheology of complex fluids. Rheology of composite biological materials.</td></tr>
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PROGRAM

I) CONSTITUTIVE EQUATIONS OF NEWTONIAN FLUIDS

Fundamentals of fluids mechanics. Lagrangian and Eulerian representations. The ideal fluid model. Euler and Lamb-Gromeka equations. The model of linear viscous fluid. First and second viscosity coefficients. Navier-Stokes equations.

II) VISCOELASTICITY. EXPERIMENTAL METHODS IN RHEOLOGY

NON-NEWTONIAN LIQUIDS. Non-Newtonian liquids with time-independent behavior. Non-Newtonian liquids with time-dependent behavior: Tixotropy and rheopexy. Experimental methods: Viscometry.

LINEAR VISCOELASTICITY. General constitutive equation. Viscoelastic moduli. Viscoelastic models: The generalized Kelvin-Voigt and Maxwell models. Viscoelastic materials in oscillatory regime. Experimental methods.

NON-LINEAR VISCOELASTIC PHENOMENA. Non-linear phenomena. Normal stress differences (N1 and N2). Observable effects of N1 and N2: Weissenberg effect, die swell, flow patterns in mixing process. Experimental methods for measuring N1 and N2.

III) RHEOLOGY OF COMPLEX FLUIDS
Colloids and suspensions. Hydrodynamic effects and rigid spheres. Stable and unstable (repulsive and attractive interactions, respectively) complex fluids. Tixotropy and yield stress. Thickening and dilatancy. Rheometry of suspensions. Structural models. Simulation at particle scale. Interfacial rheology. Advanced complex fluids (non-spherical particles; viscoelastic media; ferrofluidics; electro- and magneto-rheology). Advanced techniques (non-conventional confined fluids; tribo-rheology and microrheology).

IV) RHEOLOGY OF COMPOSITE BIOLOMATERIALS.
Polymeric liquids and gels. Biopolymers. Biological tissues. Effect of inclusions in polymer matrices. Experimental techniques: macrorheology; microrheology of living cells; nanoindentation in extracellular matrices.

EXPERIMENTAL PROGRAM:

- Computer simulation in complex fluids.
- Rheometry in steady-state regime (viscosity; yield stress) or oscillatory regime (viscoelastic moduli) of:
    - Emulsions, suspensions, and polymeric liquids and gels.
    - Pharmaceutical and cosmetic materials.
    - Asphalts, oils, greases, multigrade lubricants.
    - Other industrial products: paints, ink, cellulose, ceramics suspensions, liquid detergents.
    - Electro- and magnetirheological fluids.
    - Biopolymers.

BIBLIOGRAPHY

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