EUROMECH Newsletter 25

European Mechanics Society May 2004

www.euromech.cz

President's Introduction

I am very pleased to inform all EUROMECH *members of the outcome of the recent* EUROMECH *Council elections, as reported in detail elsewhere in this Newsletter. Let me here very simply welcome to the Council the following distinguished colleagues: Professor Ambrósio of Lisboa (Portugal, Solids), Professor Jensen of Aalborg (Denmark, Solids), Professor Lohse of Twente (The Netherlands, Fluids), Professor Schrefler of Padova (Italy, Solids) and Professor Schröder of Aachen (Germany, Fluids). They will serve on the Council for six years from 1 January 2004. We will greatly benefit from their involvement in all aspects of* EUROMECH *activities and we wish them all a highly successful term of office.*

I would also like to thank the other candidates who stood for election and did not on this occasion get elected. Members will note that there was strong support for all of them and I hope very much that they will remain actively involved in EUROMECH*.*

The Officers for 2004 are: P. Huerre (President), H.H. Fernholz (Vice-President), M. Okrouhlik (Secretary-General), E.J. Hopfinger (Treasurer). They will be assisted by B. Schrefler and W. Schröder as Associate-Secretary-General and Associate-Treasurer respectively.

As always the officers and the Council will do their best to serve our Society and they welcome any input on your part to further enhance our program of activities.

Patrick Huerre

President, EUROMECH

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Elections to the EUROMECH Council

At the end of 2003, five seats on the EUROMECH Council became vacant. After consultation with the advisory board, the affiliated organizations and suggestions made by EUROMECH members, the following EUROMECH members stood for election to the Council for a six-year term starting 1 January 2004.

Slot no. 1	B. Schrefler (S)	
2	W. Schröder (F)	
3	P. Gudmundsen (S)	H.M. Jensen (S)
4	D. Lohse (F)	T. Rösgen (F)
5	J.A.C. Ambrosio (S)	J. Pamin (S)

Generally, two candidates stand for one seat and this was the case in slots 3 to 5. This rule is not an obligation, imposed by the statutes, and when there are good reasons this unwritten rule needs not be applied. This was the case in slots 1 and 2 because B. Schrefler and W. Schröder have accepted to serve, respectively, as Secretary General and as Treasurer starting officially in January 2005.

The ballot sheet was sent to 1020 regular EUROMECH members and had to be returned to the Treasurer's Office on 15 December at the latest. A total of 341 ballots were returned by this deadline which is just slightly more than 1/3 of the ballots sent out and required by the statutes for the election to be valid. The ballots which arrived late (a total of 17) were not taken into account.

The tallying was performed by two EUROMECH members (L. Davoust, and E.J. Hopfinger) and the assistant to the Treasurer, G. Chavand. Of the 341 votes cast, 125 were undecided. The result is as follows:

Slot no. 1	B. Schrefler	170		
2	W. Schröder	163		
3	P. Gudmundson	75	H.M. Jensen	77
4	D. Lohse	106	T. Rösgen	55
5	J.A.C. Ambrosio	96	J. Pamin	63

B. Schrefler (Italy), **W. Schröder** (Germany), **H.H. Jensen** (Denmark), **D. Lohse** (The Netherlands) and **J.A.C. Ambrosio** (Portugal) are, therefore, elected to the EUROMECH Council. The composition of the new Council is given in this Newsletter.
Thank you for your support and collaboration.

Grenoble, 19 January 2004
E.J. Hopfinger, Treasurer

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EUROMECH Young Scientist Prizes
Awarded at the fifth EUROMECH Fluid Mechanics Conference
Toulouse, August 2003

Prize for the best oral presentation:

Philippe Marmottant (University of Twente, The Netherlands)

with

How ultrasound driven bubbles act on lipid membranes

Prize for the best poster presentation:

Silke Guenther (University of Technology, Darmstadt, Germany)

with

Vibrating grid turbulence scaling laws in inertial and rotating systems

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Dr Marmottant has been a Postdoc since 2001 in the Physics of Fluids group headed by Prof. Detlef Lohse at the University of Twente (The Netherlands). He works on a project on the applications of microbubbles for ultrasound imaging and therapy. His research interests are centered on the effect of bubble oscillations, ranging from the rupture of cell membranes for drug delivery, to small scale directed transport of liquids in microfluidic applications.

His personal interests are, amongst others, cross-country running and ski-mountaineering.

Ms Guenther is currently enrolled in a doctoral (PhD) program in the Department of Hydromechanics and Hydraulics at the University of Technology in Darmstadt, Germany. Her supervisor is Prof. M. Oberlack. Her area of interest is the statistical modelling of turbulence with the help of scaling laws, gathered from Lie-group analysis. Currently she is examining the flow case of shear-free, turbulent diffusion produced by an oscillating grid.

In her leisure time she has been a member of the German national team for modern pentathlon since 1994, and has participated nine times in the World Championships.

EUROMECH Young Scientist Prizes
Awarded at the fifth EUROMECH Solid Mechanics Conference
Thessaloniky, August 2003

Prize for the best oral presentation:

Athina Markaki (University of Cambridge, UK)

with

Elastic properties of thin sandwich panels with fibrous metallic cores

Prize for the best poster presentation:

Cihan Tekoglu (University of Groningen, The Netherlands)

with

Identification of Cosserat constants for cellular materials

Dr A.E. Markaki is a Post-doctoral Research Associate funded by the Cambridge-MIT Institute, Department of Materials Science & Metallurgy, Cambridge University, UK. Her research interests are centred on the development of various lightweight metallic and composite systems, particularly those incorporating metallic fibres, for various application areas in which structural performance requirements are combined with functional characteristics, such as heat transfer or noise attenuation. She is also interested in the development of devices based on intelligent actuation control for biomedical applications such as prosthetic implants.

In her free time, she enjoys reading, music and other cultural activities and also takes part in a variety of sporting activities.

Mr Tekoglu, born in Ankara, studied for his Bachelor's and Master's degrees in mechanical engineering at the "Middle East Technical University", also located in Ankara. Currently, he is working at the University of Groningen, in The Netherlands, as a research assistant. His project is about micromechanics of cellular materials, and sponsored by FOM and NIMR, both of which are Dutch scientific organizations.

Outside of his studies, he also enjoys playing chess and basketball, and sometimes football.

CONSERVATION LAWS COMMON IN THE MECHANICS OF SOLIDS AND FLUIDS

Franz Ziegler[1]

Recipient of the EUROMECH Solid Mechanics Prize 2003

1 Introduction

Research in Mechanical Sciences has reached a level where a division into Mechanics of Solids and Mechanics of Fluids seems to be quite natural and adequate. In Europe, this fact is also apparent for the biannual conferences, The European Fluid Mechanics Conference and The European Solid Mechanics Conference, held in the same year but at different locations and tenures with a rather small overlap of attendees. Similarly, the European Journal of Mechanics appears in two separate volumes, A-Solids and B-Fluids. Even computationally, such a division by the aggregate state is reflected by the sets of complications encountered in the most commonly applied Finite Element Method. When considering a simple (point-) continuum, fluid or solid, the basis of the division is already found in kinematics. In Solid Mechanics, in general, initially a (stress-free) reference state is considered and the motion and deformation evolve as functions of time in the so called Lagrangean or material description. In general, Fluid Mechanics relies on the Eulerian or spatial description, where locally a time dependence of the state is observed in nonstationary problems only. Of course, there are other physical reasons, e.g., tensor analysis is a must in Solid Mechanics and is not too often encountered in Fluid Mechanics, two body wave speeds in elastic solids cause sophisticated problems in wave propagation when compared to an acoustic medium, etc. However, there are materials where the border does not exist, e.g., bodies which creep over long time scales, or smart materials etc. Temperature effects and electro-magnetic fields are to be considered in both parts of Mechanics.

Engineering curricula on the undergraduate and the graduate level strongly depend on Mechanics. Solid Mechanics and Fluid Mechanics, when taught in separate classes at Universities to undergraduate students, however, cause more problems than furthering the understanding of modeling and analysis. There are only a few textbooks available where the conservation laws are presented in a suitable form for both fields. It is common practice, based on historical developments, to arrange the course on Fluid Mechanics after Statics, Dynamics and Strength of Materials, the latter three solely devoted to solids. Students then

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hardly recognize equilibrium conditions, conservation of mass and momentum etc. as the common basis of Mechanical Sciences. At the graduate level this two-world philosophy is even intensified. Just a simple example of too late or "not-at-all" understanding is the model of incompressible flow or isochoric deformation, which should be recognized by inspection of the continuity equation in Eulerian description, not at all taught to the beginners despite it is just part of kinematics. The classical articles in the Handbook of Physics are possibly too mathematical to attract the attention of engineering students.

In the following, an attempt is made to bridge the gap between material and spatial descriptions of the conservation laws based on "simple modeling" and the notion of production terms of time rates of change, common even to other fields, such as Economics etc. Such an engineering view led to the translation of [1] (originally published in German) into English, [2], with adoption by a few US-Universities, and, recently, into Russian [3]. Since tutorial aspects take a lead, all mechanical fields are assumed to be properly smooth, continuous or differentiable, i.e., singular surfaces are not considered at all. For a recent exposition on the latter see Irschik [4].

2 Conservation of mass-kinematics

Kinematics, with basic definitions of displacements, velocity and acceleration, strain and strain measurement and the definition of rigid body motion should be the first topic in education. The continuum and the material points are to be based on mass. Behind the mathematical definition of density, i.e., the mass per unit of volume,

$$\rho = \lim_{\Delta V \to 0} \frac{\Delta m}{\Delta V}, \quad [\rho] = \mathrm{kg/m^3} \tag{1}$$

stands "hidden" a quite variable size of the material points when comparing the range, say from fine structured metals to mass-concrete, where the latter is a mixture of cement and gravel with sizes of up to 0.1 m or even more. Density is a mean value over a sufficiently large number of constituents and thus the size of material points ranges from less than 10^{-6} to more than 2×10^{-1} m.

Commonly, mass is conserved during motion or deformation.

2.1 Conservation of mass in material description

The distribution of mass is assumed known in the reference configuration, $\rho_0(X_i)$, referred to a Cartesian coordinate system $X_i, i = 1, 2, 3$, named material coordinates. Each material point is mapped into the instant configuration, conveniently referred to the same coordinate system, $x_i(t; X_1, X_2, X_3) =$

$X_i + u_i(t; X_1, X_2, X_3)$, by the displacement vector $\vec{u}$ in the material or Lagrangean description. No external sources of mass supply are considered in the material volume $V(t)$, hence, total mass is preserved,

$$\frac{\mathrm{d}m}{\mathrm{d}t} = 0, \quad m = \int_{V_0} \rho_0(X_i)\mathrm{d}V_0 = \int_{V(t)} \rho(t, x_i)\mathrm{d}V \tag{2}$$

Mapping of the differential volumes is supplied by mathematics, where $F_{ij} = \frac{\partial x_i}{\partial X_j}$ denotes the deformation gradient, and $J = \det\{F_{ij}\}$ is the Jacobian determinant of the mapping, representing the dilatation of the infinitesimal volume,

$$\mathrm{d}V = J\mathrm{d}V_0, \quad J = \det\{F_{ij}\} \tag{3}$$

where

$$e = \frac{\mathrm{d}V - \mathrm{d}V_0}{\mathrm{d}V_0} = J - 1 = \sum_{i=1}^{3} \varepsilon_{ii} + \text{nonlinear terms} \tag{4}$$

is the dilatation, which is approximated by the first invariant of the strain tensor for small deformations. Since Eq. (2) must hold for all subdomains in the reference configuration, the integrands must be equal. With Eq. (3) substituted, the local compressibility relation becomes

$$\rho(t; X_i) = J^{-1}\rho_0(X_i), \quad J^{-1} = \det\{F_{ij}^{-1}\} \tag{5}$$

Actually, Eq. (5) does not provide insight into the degree of approximation of the assumption of incompressibility.

2.2 Conservation of mass in spatial description

In the spatial or Eulerian description we consider the velocity of a material point as a function of its instant location and possibly of time, $\vec{v}(x_i; t)$, and consequently assume the streamlines to be known. The time rate of the mass $m_{V^*}(t)$, instantly contained in an assigned, spatially fixed volume, the control volume V^*, that is enclosed in the control surface ∂V^*, with the flux of mass through the surface considered as the only production term in the absence of external sources in the volume, is simply given by

$$\frac{\mathrm{d}m_{(V^*)}(t)}{\mathrm{d}t} = \int_{V^*} \frac{\partial \rho}{\partial t}\mathrm{d}V^* = -\oint_{\partial V^*} \mu \mathrm{d}S \tag{6}$$

where, see Fig. 1, the mass flow rate per unit of the control surface is, $\vec{n}$ being the normal pointing outward,

$$\mu = \rho(\vec{v}.\vec{n}), \quad [\mu] = \mathrm{kg/sm^2} \tag{7}$$

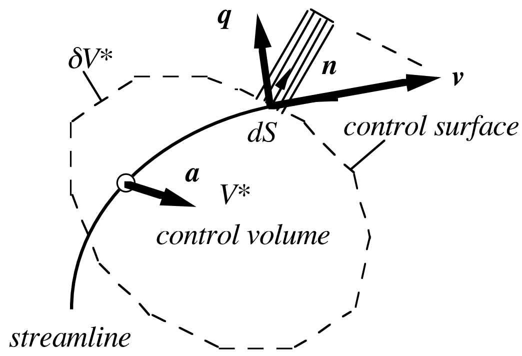

Figure 1: *Control volume considered fixed in space. Normal $\vec{n}$ of the control surface, velocity $\vec{v}$, acceleration $\vec{a}$ and heat flux vector $\vec{q}$ are illustrated. The latter applies also to a material surface. The control surface determines the free-body-diagram, traction not shown.*

For the control volume concept see, e.g., [5]. The balance equation (6) has many applications from simple pipe flow to air-breathing propulsion engines and rockets and is a basic formula for traffic control, economics and other fields.

Considering the instant coincidence of a material volume, $V(t)$, see Eq. (2), with the control volume considered in (6), V^*, the Reynolds transport theorem results at once,

$$\frac{\mathrm{d}m}{\mathrm{d}t} = \frac{\mathrm{d}m_{(V^*)}(t)}{\mathrm{d}t} + \oint_{\partial V^*} \mu \mathrm{d}S = 0, \quad \frac{\mathrm{d}}{\mathrm{d}t}\int_{V(t)} \rho \mathrm{d}V = \int_{\partial V^*} \frac{\partial \rho}{\partial t} \mathrm{d}V^* + \oint_{\partial V^*} \mu \mathrm{d}S = 0 \tag{8}$$

For a uniquely connected control volume, the surface integral in Eq. (6) can be changed to a volume integral rendering

$$\int_{V^*} \left[\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho \vec{v})\right] \mathrm{d}V^* = 0 \tag{9}$$

which must hold for any size of the control volume. Hence, the local condition of mass conservation results, which is known as the continuity equation,

$$\frac{\partial \rho}{\partial t} + \operatorname{div}(\rho \vec{v}) = 0 \tag{10}$$

It takes the shape of its normal and more explicit form in fluid mechanics, when considering the total time derivative of the density and expanding Eq. (10),

$$\frac{\mathrm{d}\rho}{\mathrm{d}t} + \rho\,\mathrm{div}\,\vec{v} = 0, \quad \frac{\mathrm{d}\rho}{\mathrm{d}t} = \frac{\partial\rho}{\partial t} + (\vec{v}.\nabla)\rho \tag{11}$$

Solving for the geometric condition on the velocity field and using rules of differentiation known even to beginners, yields

$$\mathrm{div}\,\vec{v} = \frac{\mathrm{d}}{\mathrm{d}t}(\ln\rho) \tag{12}$$

Since the logarithmic function mitigates changes in density, the assumption of incompressibility, $\mathrm{div}\,\vec{v} = 0$, holds good for rather large changes of the density caused by pressure fluctuation, e.g., in air-flow.

Since the rotation of the velocity field, $\mathrm{curl}\,\vec{v}$, should be determined in kinematics and interpreted as the angular velocity of a small neighborhood of the material points,

$$\vec{\omega} = \frac{1}{2}\mathrm{curl}\,\vec{v} \tag{13}$$

the approximation in the consideration of an irrotational and incompressible flow becomes evident and, with the existence of the velocity potential assured by mathematics, the homogeneous Eq. (12) yields at once the Laplace equation – time is a parameter entering the solution only through moving boundaries – the boundary condition, B.C., at a rigid wall at rest is indicated,

$$\Delta\phi = 0, \quad \vec{v} = \mathrm{grad}\,\phi \quad \text{B.C.}: v_n = (\vec{v}.\vec{n}) = \frac{\partial\phi}{\partial n} = 0 \tag{14}$$

The balance of Eq. (6) can be applied to a moving control volume V^{**}. In most applications it suffices to prescribe a rigid body motion to the reference system attached at a point A' to the shape invariant control surface ∂V^{**}. With given velocity $\vec{w}_A$ and given angular velocity $\vec{\Omega}$, the velocity field $\vec{w}$ is expressed by the basic formula of rigid body motion, $|\vec{r}\,'| = \mathrm{const}$,

$$\vec{w} = \vec{w}_A + \vec{\Omega} \times \vec{r}\,' \tag{15a}$$

Hence, Eq. (7) changes to the net efflux rate

$$\mu^{**} = \rho(\vec{v} - \vec{w}).\vec{n} \tag{15b}$$

and, since the density is a scalar function, Eq. (6) remains formally the same when μ^{**} is substituted

$$\frac{\mathrm{d}m_{(V^{**})}(t)}{\mathrm{d}t} = \int_{V^{**}} \frac{\partial'\rho(t,\vec{r}\,')}{\partial t}\mathrm{d}V^{**} = -\oint_{\partial V^{**}} \mu^{**}\mathrm{d}S^{**} \tag{16}$$

This balance equation simplifies if the observer in the moving frame sees a constant density distribution.

It is believed that such early discussions would enrich kinematics and would grab the attention of a European freshman.

3 Dynamics

The Euler-Cauchy equation of motion of Newtonian Mechanics holds good for all material points, $\vec{a}$ is the absolute acceleration, $\vec{b}$ the body force and $\vec{\sigma}_i$ is the Cauchy stress vector,

$$\vec{f} = \rho\vec{a}, \quad \vec{f} = \vec{b} + \sum_{i=1}^{3} \frac{\partial \vec{\sigma}_i}{\partial x_i}, \quad \vec{\sigma}_i = \sum_{j=1}^{3} \sigma_{ij}\vec{e}_j, \quad \vec{v} = \frac{\mathrm{d}\vec{r}}{\mathrm{d}t}, \quad \vec{a} = \frac{\mathrm{d}\vec{v}}{\mathrm{d}t} \tag{17}$$

From equilibrium considerations in the free-body-diagram, it is known in statics that the summation of the force density, $\vec{f}$, renders the resultant of the external forces, say $\vec{R}$, with traction denoted $\vec{\sigma}_n$,

$$\int_V \vec{f}\mathrm{d}V = \int_V \vec{b}\mathrm{d}V + \oint_{\partial V} \vec{\sigma}_n \mathrm{d}S = \vec{R} \tag{18}$$

which is supposed to vanish as a necessary condition for equilibrium. Hence, Eq. (18) holds good also for a free-body-diagram at any instant of time. Integration can be extended over any material volume or, alternatively, over any control volume.

3.1 Conservation of momentum in material description

Integration of Eq. (17) over a material volume, a free-body-diagram at a time instant, t, yields, considering the constant mass and the consequently allowed interchange of time differentiation and volume integration, Eq. (18) being taken into account, where $\mathrm{d}m = \rho\mathrm{d}V$ is the mass element, and the subscript C denotes the center of mass,

$$\int_{V(t)} \rho\vec{a}\mathrm{d}V = \frac{\mathrm{d}^2}{\mathrm{d}t^2}\int_{m=\mathrm{const.}} \vec{r}\mathrm{d}m = \frac{\mathrm{d}^2}{\mathrm{d}t^2}(m\vec{r}_C) = m\vec{a}_C = \vec{R} \tag{19}$$

The resulting Eq. (19) implies the fact that internal forces do not accelerate the center of mass. The definition of momentum (impulse),

$$\mathrm{d}\vec{I} = \vec{v}\mathrm{d}m, \quad \vec{I} = \int_m \vec{v}\mathrm{d}m = \frac{\mathrm{d}}{\mathrm{d}t}\int_{m=\mathrm{const.}} \vec{r}\mathrm{d}m = m\vec{v}_C \tag{20}$$

allows for a reformulation of Eq. (19). Note the mass moment of first order apparent in Eqs. (19) and (20).

The time derivative of Eq. (20) when substituted into Eq. (19) thus relates the rate of momentum to the action of the external forces,

$$\frac{\mathrm{d}\vec{I}}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\int_{V(t)} \rho\vec{v}\mathrm{d}V = \vec{R} \tag{21}$$

Time integration renders conservation of momentum in the material description; note the resulting impulse of the external forces

$$\vec{I}(t) - \vec{I}(t_0) = \int_{t_0}^{t} \vec{R}\mathrm{d}t \tag{22}$$

Multiplying Eq. (17) with the volume element $\mathrm{d}V$ with $\mathrm{d}m = \rho\mathrm{d}V$ taken into account, and taking its moment about the origin O of the inertial frame, render, with the definition of the moment of momentum (angular momentum or angular impulse)

$$\mathrm{d}\vec{H}_0 = \vec{r} \times \vec{v}\mathrm{d}m \tag{23}$$

added,

$$\frac{\mathrm{d}\vec{H}_0}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\int_m \vec{r} \times \vec{v}\mathrm{d}m = \int_m \frac{\mathrm{d}}{\mathrm{d}t}(\vec{r} \times \vec{v})\mathrm{d}m = \int \vec{r} \times \vec{f}\mathrm{d}m = \vec{M}_0 \tag{24}$$

Eq. (24) is complementary to Eq. (21) and reflects the equilibrium condition of the vanishing resulting moment of the external forces of statics. It is quite easy to show that the center of mass can be chosen as the reference point for taking the moments, and, despite its motion, the rate of the absolute angular momentum is related to the resulting moment of the external forces:

$$\frac{\mathrm{d}\vec{H}_C}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\int_m \vec{r}\,'\times\vec{v}\mathrm{d}m = \int_{V(t)} \vec{r}\,'\times\vec{f}\mathrm{d}V = \vec{M}_C = \int_{V(t)} \vec{r}\,'\times\vec{b}\mathrm{d}V + \oint_{\partial V(t)} \vec{r}\,'\times\vec{\sigma}_n\mathrm{d}S \tag{25}$$

$\vec{r}\,'$ is the position vector pointing from the center of mass to the mass element.

3.2 Conservation of momentum in spatial description

The mass contained in the control volume of Fig. 1 has a resulting momentum

$$\vec{I}_{(V^*)}(t) = \int_{V^*} \rho\vec{v}\mathrm{d}V^* \tag{26}$$

Its time rate is activated by the production terms, absolute acceleration of all material points in the control volume and the flow of mass through the control volume which carries momentum. Hence,

$$\frac{\mathrm{d}\vec{I}_{(V^*)}(t)}{\mathrm{d}t} = \int_{V^*} \frac{\partial(\rho\vec{v})}{\partial t}\mathrm{d}V^* = \int_{V^*} \rho\vec{a}\mathrm{d}V^* - \oint_{\partial V^*} \mu\vec{v}\mathrm{d}S \tag{27}$$

Substituting Eq. (17) and using the result (18) yield at once

$$\frac{\mathrm{d}\vec{I}_{(V^*)}(t)}{\mathrm{d}t} + \oint_{\partial V^*} \mu\vec{v}\mathrm{d}S = \vec{R} \tag{28}$$

Since $\vec{R}$ is the resultant of the external forces acting on the control volume, the control surface defines the free-body-diagram. In case of a time invariant resulting momentum, Eq. (28) becomes a static relation: the net efflux of momentum equals the resulting external force acting on the control volume, especially given by the sum of the traction on the control surface in absence of dynamically relevant body forces.

Reynolds transport theorem becomes, analogous to Eq. (8), considering Eqs. (21) and (28)

$$\begin{aligned} \frac{\mathrm{d}\vec{I}}{\mathrm{d}t} &= \frac{\mathrm{d}\vec{I}_{(V^*)}(t)}{\mathrm{d}t} + \oint_{\partial V^*} \mu\vec{v}\mathrm{d}S = \vec{R}, \\ \frac{\mathrm{d}}{\mathrm{d}t}\int_{V(t)} \rho\vec{v}\mathrm{d}V &= \int_{V^*} \frac{\partial(\rho\vec{v})}{\partial t}\mathrm{d}V^* + \oint_{\partial V^*} \mu\vec{v}\mathrm{d}S = \vec{R} \end{aligned} \tag{29}$$

Selecting the point of reference for taking the moments fixed in the inertial system and noting the analogous form of Eqs. (21) and (24) render at once the companion to Eq. (28) for the angular momentum,

$$\frac{\mathrm{d}\vec{H}_{(V^*)_0}(t)}{\mathrm{d}t} + \oint_{\partial V^*} (\vec{r} \times \mu\vec{v})\mathrm{d}S = \vec{M}_0 \tag{30}$$

where $\vec{M}_0$ is the resulting moment of the external forces acting on the control volume.

Considering a rigidly moving control volume, Eqs. (15a) and (15b) apply and the latter is to be substituted in Eq. (28) and Eq. (30). When the reference point in the latter equation is changed to the accelerated point A' fixed to the moving frame, an additional term must be considered as shown below. Further, the vectors of momentum and angular momentum are projected to the moving frame and consequently, their time derivative consist of the "hopefully" vanishing, nonstationary part (the rate of change relative to the moving frame indicated by $\frac{\mathrm{d}'}{\mathrm{d}t}$) and the change due to the rotation of the reference frame with prescribed angular velocity $\vec{\Omega}$,

$$\frac{\mathrm{d}'\vec{I}_{(V^{**})}(t)}{\mathrm{d}t} + \vec{\Omega} \times \vec{I}_{(V^{**})} + \oint_{\partial V^{**}} \mu^{**} \vec{v} \mathrm{d}S^{**} = \vec{R}, \tag{31}$$

$$\frac{\mathrm{d}'\vec{H}_{(V^{**})A}(t)}{\mathrm{d}t} + \vec{\Omega} \times \vec{H}_{(V^{**})A} + m_{(V^{**})}(t) \vec{r}'_{MA} \times \vec{a}_A + \oint_{\partial V^{**}} (\vec{r}' \times \mu^{**} \vec{v})\, \mathrm{d}S^{**} = \vec{M}_A \tag{32}$$

In deriving the Reynolds transport theorem for an arbitrarily moving control volume, the concept of fictitious particles moving with the velocity $\vec{w}$ has proven useful, see Truesdell and Toupin [7, sect. 81] for details. Conservation of linear and angular momentum is crucial for applications, e.g., to all kinds of turbines and propulsion engines. The thrust of rockets and of air-breathing propulsion engines is easily determined. In the general form of Eqs. (31) and (32), these engines can be considered under maneuvering flight conditions.

4 Conservation of energy and the first law of thermodynamics

The power density, i.e., the power per unit of volume, is related to the rate of change of kinetic energy by scalar multiplication of the Euler-Cauchy equation of motion (17) with the velocity,

$$\frac{\mathrm{d}P}{\mathrm{d}V} = \vec{f}.\vec{v} = \rho \left(\vec{v}.\frac{\mathrm{d}\vec{v}}{\mathrm{d}t} \right) = \rho \frac{\mathrm{d}}{\mathrm{d}t} \left(\frac{v^2}{2} \right) \tag{33}$$

where $\vec{a} = \frac{\mathrm{d}\vec{v}}{\mathrm{d}t}$ has been substituted and $(\vec{v}.\vec{v}) = v^2$ is inserted; note the chainrule of differentiation in Eq. (33). The local relation (33) is alternatively integrated over a material volume containing a mass $m = \text{const.}$ or over a control volume instantly containing a mass $m_{(V^*)}(t)$.

Keeping the local density form preserved, Eq. (33) is multiplied by $\mathrm{d}t$ and subsequently integrated over the arclength of a definitely selected streamline, noting $\vec{v}\mathrm{d}t = \vec{e}_t \mathrm{d}s$ pointing in the tangential direction of the streamline, thus, yielding the celebrated (generalized) Bernoulli equation of fluid dynamics. It takes on a rather simple form when the Euler equation of motion of an inviscid flow is considered, where $\vec{f} = \vec{b} - \operatorname{grad} p$, with p the (isotropic) pressure, is substituted in Eq. (33).

4.1 Conservation of energy in material description

Integration over a material volume renders with the definition of kinetic energy

$$T(t) = \int_m \frac{v^2}{2} \mathrm{d}m \tag{34}$$

the power law, relating the rate of kinetic energy to the sum of powers of the external and the internal forces at any instant of time

$$\frac{\mathrm{d}T(t)}{\mathrm{d}t} = P^{(e)} + P^{(i)} \tag{35}$$

Time integration yields the law of mechanical work: the work done by external and internal forces equals the increase in kinetic energy. In the case of irrotational force fields, a potential function exists and the law of mechanical work becomes the conservation law of mechanical energy, to hold for conservative systems. We assume here the existence of the elastic potential $U = \int_m U' \mathrm{d}m = -W^{(i)}$, with its density per unit mass denoted U', of the internal forces only – it equals the negative work of the internal forces – to rewrite Eq. (35) as follows

$$\frac{\mathrm{d}}{\mathrm{d}t}(T + U) = P^{(e)}, \quad \frac{\mathrm{d}}{\mathrm{d}t} \int_m \left(\frac{v^2}{2} + U' \right) \mathrm{d}m = P^{(e)}, \quad \frac{\mathrm{d}U}{\mathrm{d}t} = -\frac{\mathrm{d}W^{(i)}}{\mathrm{d}t} = -P^{(i)} \tag{36}$$

Equation (36) must be generalized to account for the power supplied by non-mechanical fields. At first, the elastic potential density, U', is replaced by the more general internal energy per unit of mass, u. In the case of the action of external sources of heat supply in the material volume, power $P^{(q)}$, with heat flux through the material surface, $q_n = (\vec{q}.\vec{n})$, considered, see also Fig. 1, Eq. (36) is generalized, and the rate of total energy becomes,

$$\frac{\mathrm{d}}{\mathrm{d}t} \int_m \left(\frac{v^2}{2} + u \right) \mathrm{d}m = P^{(e)} + P^{(q)} - \oint_{\partial V(t)} q_n \mathrm{d}S \tag{37}$$

Subtraction of the generally valid Eq. (35) yields at once the first law of thermodynamics in its standard form of the rate of internal energy, the kinetic energy and the power of the external forces, $P^{(e)}$, are "eliminated",

$$\frac{\mathrm{d}}{\mathrm{d}t} \int_m u \mathrm{d}m = -P^{(i)} + P^{(q)} - \oint_{\partial V(t)} q_n \mathrm{d}S \tag{38}$$

For the boundary value problems of heat conduction in solids, see [6]; for electro-magnetic fields, see [7].

4.2 Conservation of energy in spatial description

Considering the control volume V^* fixed in space and instantly coinciding with a material volume $V(t)$, the Reynolds transport theorem is easily applied to both the power law of mechanics in its form of Eq. (35) and Eq. (37), considering the heat flux through the control surface, see Fig. 1,

$$\frac{\mathrm{d}T(t)}{\mathrm{d}t} = \frac{\mathrm{d}T_{(V^*)}(t)}{\mathrm{d}t} + \oint_{\partial V^*} \mu \frac{v^2}{2} \mathrm{d}S$$

$$\frac{\mathrm{d}}{\mathrm{d}t} \int_m \frac{v^2}{2} \mathrm{d}m = \int_{V^*} \frac{\partial}{\partial t} \frac{(\rho v^2)}{2} \mathrm{d}V^* + \oint_{\partial V^*} \mu \frac{v^2}{2} \mathrm{d}S = P^{(e)}(t) + P^{(i)}(t) \tag{39}$$

and

$$\begin{aligned} \frac{\mathrm{d}}{\mathrm{d}t} \int_m \left(\frac{v^2}{2} + u\right) \mathrm{d}m &= \int_{V^*} \frac{\partial}{\partial t} \left(\frac{\rho v^2}{2} + \rho u\right) \mathrm{d}V^* + \oint_{\partial V^*} \mu \left(\frac{v^2}{2} + u\right) \mathrm{d}S \\ &= P^{(e)} + P^{(q)} - \oint_{\partial V^*} q_n \mathrm{d}S \end{aligned} \tag{40}$$

Subtracting Eq. (39) from (40) yields the first law of thermodynamics for the mass $m_{(V^*)}$ in the control volume V^* in the form standard in thermodynamics. The Reynolds transport theorem when directly applied to Eq. (38) verifies the result,

$$\int_{V^*} \frac{(\partial \rho u)}{\partial t} \mathrm{d}V^* + \oint_{\partial V^*} \mu u \mathrm{d}S = -P^{(i)} + P^{(q)} - \oint_{\partial V^*} q_n \mathrm{d}S \tag{41}$$

Since scalar quantities are apparent in Eq. (41), it is easily generalized to account for a rigidly moving control surface, following the reasoning leading to Eq. (16). The transition from Mechanics to Thermodynamics by means of generalizing the power law of Mechanics seems to be straightforward and may be attractive to beginners in Engineering curricula.

5 The Lagrange equations of motion

Applying D'Alembert's principle, i.e. the principle of virtual deformations to the instant configuration in the free-body-diagram, the virtual work of the inertia forces is included, in a discrete or discretized system, i.e., the position vector is a function of n generalized coordinates and time, $\vec{r} = \vec{r}(t; q_1, q_2, \ldots, q_n)$, the following relation is found, [2], p. 567,

$$\sum_{i=1}^{n}\left\{\int_{V(t)}\left[\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial}{\partial\dot{q}_i}\frac{v^2}{2}\right)-\frac{\partial}{\partial q_i}\frac{v^2}{2}\right]\rho\mathrm{d}V-Q_i\right\}\delta q_i=0,$$

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial T}{\partial\dot{q}_i}\right)-\frac{\partial T}{\partial q_i}=Q_i,\quad i=1,2,\ldots,n \tag{42}$$

For holonomic boundary conditions, the variations of the generalized coordinates δq_i remain independent and, hence, in the sum of Eq. (42), the terms vanish independently. For the material volume enclosing the mass $m=$ const., integration at constant time and the derivatives can be interchanged, thus rendering the Lagrange equations of motion when substituting the definition of kinetic energy, (34) – the second part of Eq. (42). Thus, the kinetic energy must be expressed as the function $T=T(t;\dot{q}_1,\dot{q}_2,\ldots,\dot{q}_n,q_1,q_2,\ldots,q_n)$. The generalized forces Q_i render the virtual work of the external and internal forces,

$$\delta W=\delta W^{(e)}+\delta W^{(i)}=\sum_{i=1}^{n}Q_i\delta q_i \tag{43}$$

Further to the tutorial aspects of this article, there might be a research interest to write these equations for a control volume. With applications in mind, e.g., to the winding of thin sheets, to deployable structures and in robotics, where small vibrations are superposed on large rigid body motions, Irschik and Holl [9] derived the proper form of the Lagrange equations of motion for a moving control volume, thereby generalizing the virtual body considerations in [8]. At first, Eq. (15b) is rewritten by substituting Eq. (5) and noting the functional dependence of the Jakobean on the current position

$$\mu^{**}=J^{-1}(x_i;q_k(t);t)\rho_0(X_i)(\vec{v}-\vec{w}).\vec{n} \tag{44}$$

The Reynolds transport theorem is applied to the term containing the total time derivative in Eq. (42) rendering the Lagrange equations of motion for the control volume

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial_w T_{(V^{**})}}{\partial\dot{q}_k}\right)-\frac{\partial_w T_{(V^{**})}}{\partial q_k}+\oint_{\partial V^{**}}\left[\mu^{**}\frac{\delta}{\delta\dot{q}_k}\left(\frac{v^2}{2}\right)-\frac{v^2}{2}\frac{\delta\mu^{**}}{\delta\dot{q}_k}\right]\mathrm{d}S^{**}=Q_k \tag{45}$$

The subscript w indicates that we deal with fictitious particles moving with velocity $\vec{w}$. The notation of partial derivatives $\frac{\delta}{\delta\dot{q}_k}$, apparent in Eq. (45), has been chosen to refer to the current state, i.e., the actual position of the particles and the normal $\vec{n}$ have to be kept fixed when taking the derivative. The generalized forces are determined as usual by comparing their virtual work to the virtual work of the external and the internal forces in the free-body-diagram keeping $t=$ const.

6 Concluding remarks

Considering the conservation of mass in the undergraduate teaching of kinematics illustrates physical modeling at an early stage. Conservation of momentum and of energy in both formulations taught in one course of Mechanics is paralleled with illustrative examples. More advanced, even the Lagrange equations of motion should be made available in the spatial formulation. Modern accounts of the conservation laws are given in [10] and [11]. Historical remarks are critically discussed in the recent related article [12]. The author kindly invites critical comments, e.g., by Email: franz.ziegler@tuwien.ac.at

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First Announcement and Call for Papers
10th EUROMECH European Turbulence Conference
ETC10

Tuesday 29 June – Friday 2 July, 2004

Trondheim, Norway

http://www.etc10.ntnu.no

The 10th European Turbulence Conference, organized by EUROMECH (the European Mechanics Society), will take place at the Norwegian University of Science and Technology (NTNU) in Trondheim.

The conference aims to provide an international forum for exchange of information on most fundamental aspects of turbulent flows, including instability and transition, intermittency and scaling, vortex dynamics and structure formation, transport and mixing, turbulence in multiphase and non-Newtonian flows, reacting and compressible turbulence, acoustics, control, geophysical and astrophysical turbulence, and large-eddy simulations and related techniques.

Eight prominent scientists have already accepted the invitation to give keynote lectures in their respective field of expertise. These are (in alphabetical order):

- G. Boffetta (Italy) - intermittency and scaling
- C. Cambon (France) - stratified and rotating turbulence
- D. Henningson (Sweden) - transition and control
- Y. Kaneda (Japan) - turbulence simulations
- T.S. Lundgren (USA) - turbulence theory
- S.B. Pope (USA) - reacting turbulent flows
- N. Sandham (UK) - aeroacoustics
- Z. Warhaft (USA) - scalar mixing.

In addition to these 8 invited lectures, contributions are solicited from the worldwide turbulence research community. The paper selection will be made by the EUROMECH Turbulence Conference Committee on the basis of two-page abstracts submitted by e-mail to abstract@etc10.ntnu.no by 31 October 2003. The proceedings 'Advances in Turbulence X' will be published by CIMNE and made available at the conference. For further information, or to register your interest in ETC10, please visit the website http://www.etc10.ntnu.no. Any enquiries should be sent to admin@etc10.ntnu.no

Announcement and Call for Papers
Fifth EUROMECH Nonlinear Dynamics Conference
ENOC-2005

7–12 August 2005

Eindhoven University of Technology, The Netherlands

http ://www.enoc2005.tue.nl

The Fifth EUROMECH Nonlinear Dynamics Conference (abbreviated as ENOC-2005) will be held at the Eindhoven University of Technology in The Netherlands from 7–12 August 2005.

The present ENOC Conferences aim at covering the complete field of Nonlinear Dynamics, including Multibody Dynamics and couplings to Control and to Optimization.

Compared to the previous ENOC Conferences the structure of ENOC-2005 has been changed to a far-reaching extent. As usual, a limited number of General Lectures will be delivered by renowned scientists in different sub-fields of Nonlinear Dynamics. Besides, a substantial number of Mini-Symposia on major and challenging topics will be organized by recognized scientists, acting also as chairpersons of those Mini-Symposia.

General Lecturers :

- Prof. Thor Fossen (Norway)
- Prof. Jacques Laskar (France)
- Prof. Mark Levi (USA)
- Dr. Leo Maas (The Netherlands)
- Prof. Gabor Stépán (Hungary)
- Prof. Jon Juel Thomsen (Denmark)

Abstract Submission

Abstracts should be submitted in plane ASCII before 1 December 2004 by using the Abstract Submission menu at the ENOC-2005 website. The maximum length of each abstract is limited to 500 words with up to three references. Only plain text is to be used for the abstracts. All abstracts submitted will be reviewed for presentation at the ENOC-2005 Conference. All abstracts of papers accepted for presentation will be printed in the Abstract Book.

More information can be found on the ENOC-2005 website, which will be updated regularly. Alternatively, information is also available at the ENOC-2005 Conference Secretariat.

Web : http ://www.enoc2005.tue.nl **Email : enoc2005@tue.nl**

EUROMECH Conferences in 2004 and 2005

The general purpose is to provide opportunities for scientists and engineers from all of Europe to meet and to discuss current research. Europe is a very compact region, well provided with conference facilities, and this makes it feasible to hold inexpensive meetings.

The fact that the EUROMECH Conferences are organized by Europeans primarily for the benefit of Europeans should be kept in mind. Qualified scientists from any country are of course welcome as participants, but the need to improve communications within Europe is relevant to the scientific programme and to the choice of leading speakers.

A EUROMECH Conference on a broad subject, such as the ESMC or the EFMC, is not a gathering of specialists all having the same research interests, and much of the communication which takes place is necessarily more in the nature of the imparting of information than the exchange of the latest ideas. A participant should leave a Conference knowing more and understanding more than on arrival, and much of that gain may not be directly related to the scientist's current research. It is very important therefore that the speakers at a Conference should have the ability to make ideas clear and interesting and should select and prepare their material with this expository purpose in mind.

EETC
10th EUROMECH European Turbulence Conference
Dates: 29 June - 2 July 2004
Location: The Norwegian University of Science and Technology Trondheim, Norway
Contact: Prof. Helge I. Andersson
E-mail: helge.i.andersson@maskin.ntnu.no
E-mail: admin@etc10.ntnu.no
Website: http://www.etc10.ntnu.no

ENOC
5th EUROMECH Nonlinear Oscillations Conference
Dates: 7–12 August 2005
Location: Auditorium Building, Eindhoven University of Technology, The Netherlands
Contact: Prof. Dick H. van Campen, Dept. Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
E-mail: D.H.v.Campen@tue.nl
Fax: +31 40 243 7175
Website: http://www.enoc2005.tue.nl

EUROMECH Colloquia in 2004, 2005 and 2006

EUROMECH Colloquia are informal meetings on specialized research topics. Participation is restricted to a small number of research workers actively engaged in the field of each Colloquium. The organization of each Colloquium, including the selection of participants for invitation, is entrusted to a Chairman. Proceedings are not normally published. Those who are interested in taking part in a Colloquium should write to the appropriate Chairman. Number, Title, Chairperson or Co-chairperson, Dates and Location for each Colloquium in 2004, and preliminary information for some Colloquia in 2005, are given below.

EUROMECH Colloquia in 2004

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Vortices and field interactions
CHAIRMAN: Dr. Maurice Rossi Laboratoire de Modélisation en Mécanique, Université Pierre et Marie Curie (Paris 6), CNRS (UMR n07607) 8 rue du Capitaine Scott, 75015 Paris, France
E-MAIL: maur@ccr.jussieu.fr
CO-CHAIRPERSON: Dr. Andrew Gilbert, School of Mathematical Sciences, University of Exeter, Exeter, EX4 4QE, UK
E-MAIL: a.d.gilbert@ex.ac.uk
CO-CHAIRPERSON: Dr. A. Maurel, CNRS, Lab. Ondes et Acoustique, ESPCI - 10 rue Vauquelin, 75005, Paris, France
E-MAIL: anges.maurel@espci.fr
EUROMECH CONTACT PERSON: Prof. Patrick Huerre
DATE AND LOCATION: 6–10 September 2004, ESPCI, 10 rue Vauquelin, 75005 Paris France
Remarks: postponed from 2003

450
Studies on Splashes, a Century after A.M. Worthington
CHAIRMAN: Professor Christophe Clanet IRPHE, Technopole de Château Gombert, 49 rue Frédéric Joliot-Curie, 13 384 Marseille, France
E-MAIL: clanet@irphe.univ-mrs.fr
CO-CHAIRMAN: Prof. David Quéré, Physique de la Matiere Condensée, College de France 11 place Marcelin Berthelot, 75 231 Paris, France
CO-CHAIRMAN: Prof. Jean-Marc Chomaz, LADHYX, Ecole Polytechnique, Laboratoire d'hydrodynamique, 91 128 Palaiseau, France
EUROMECH CONTACT PERSON: Prof. Patrick Huerre
DATE AND LOCATION: 27–29 October 2004, Carry le Rouet, France
Remarks: postponed from 2003

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Advances in Simulation Techniques for Applied Dynamics

CHAIRMAN: Professor M. Arnold Martin-Luther-University Halle-Wittenberg, Department of Mathematics and Computer Science Institute of Numerical Mathematics, Theodor-Lieser-Str. 5, 06120 Halle (Saale), Germany
E-MAIL: arnold@mathematik.uni-halle.de
CO-CHAIRMAN: Prof. Dr.-Ing. Dr. h.c. W. Schiehlen, Institute B of Mechanics, University of Stuttgart, Germany
EUROMECH CONTACT PERSON: Prof. W. Schiehlen
DATE AND LOCATION: 1–4 March 2004, Halle, Germany
Remarks: postponed from 2003

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Large Eddy Simulation (LES), Coherent Vortex Simulation (CVS) and Vortex methods for incompressible turbulent flows

CHAIRMAN: Professor Kai Schneider L3M & CMI, Universite de Provence (Aix-Marseille I) 39, rue Joliot-Curie, 13453 Marseille Cedex 13, France
PHONE: + 33 4 91 11 85 29
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CO-CHAIRPERSON: Prof. Marie Farge, LMD-CNRS, École Normale Supérieure 75231 Paris Cedex 5, France
E-MAIL: farge@lmd.ens.fr
CO-CHAIRPERSON: Prof. Joel Ferziger, Department of Mechanical Engineering, Stanford University, Stanford, USA
E-MAIL: ferziger@ecoule.stanford.edu
EUROMECH CONTACT PERSON: Prof. Patrick Huerre
DATE AND LOCATION: 14–16 April 2004 at CIRM, Marseille, France
Remarks: accepted 2002

455

Semi-active Vibration Suppression

CHAIRMAN: Professor Michael Valasek Department of Mechanics, Faculty of Mechanical Engineering Czech Technical University, Karlovo nám. 13, 121 35 Prague 2, the Czech Republic
E-MAIL: valasek@fsik.cvut.cz
CO-CHAIRMAN: Prof. Andre Preumont, Active Structures Laboratory Department of Mechanical Engineering and Robotics Faculty of Applied Sciences Universite Libre de Bruxelles, Bruxelles, Belgium
EUROMECH CONTACT PERSON: Asoc. Prof. Miloslav Okrouhlík
DATE AND LOCATION: 2–4 July 2004, Prague, the Czech Republic
Remarks: accepted 2002

456

Experimental and Computational Biofluid Mechanics

CHAIRMAN: Prof. W. Schröder Fluid Mechanics and Institute of Aerodynamics RWTH Aachen Wuellnerstr. zw. 5 u. 7 52062 Aachen, Germany
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EUROMECH CONTACT PERSON: Prof. Patrick Huerre
DATE AND LOCATION: 4–5 October 2004, RWTH, Aachen, Germany

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Non-linear modes of vibrating systems

CHAIRMAN: Prof. Claude-Henri Lamarque ENTPE, DGCB-LGM 3 rue Maurice Audin 69518 Vaulx-en-Velin cedex, France
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CO-CHAIRMAN: Prof. Bruno Cochelin LMA-CNRS, Marseille, France
EUROMECH CONTACT PERSON: Prof. Franz Rammerstorfer
DATE AND LOCATION: 7–9 June 2004, Frejus, France

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Validitation and Identification of Non-linear Constitutive Equations in Solid Mechanics

CHAIRMAN: Prof. R.A. Vasin Institute of Mechanics, Lomonosov Moscow State University Michurinski Prosp. 1 117192, Moscow, Russia
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CO-CHAIRMAN: Prof. B.E. Melnikov St. Petersburg State Tech. University Polytechnicheskaya Street 29, 195 251 St. Petersburg, Russia
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EUROMECH CONTACT PERSON: Prof. Irina Goryacheva
DATE AND LOCATION: 21–23 September 2004, Moscow, Russia

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Mechanical Behaviour of Cellular Solids
Chairman: Prof. J.F. Ganghoffer LEMTA-ENSEM 2 Avenue de la Foret de Haye BP 160, 54504 Vandœuvre les Nancy cedex, France
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Co-chairman: Dr. P. Onck, University of Groningen, The Netherlands Euromech contact person: Prof. Eric van der Giessen
Date and location: 7–10 June 2004, Nancy, France

464
Fibre-reinforced solids: constitutive laws and instabilities
Chairman: Prof. R.W. Ogden Department of Mathematics, University of Glasgow, Glasgow G12 8QW, UK
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Co-chairman: Dr. J. Merodio, University of Cantabria, Santander, Spain
Date: 28 September – 1 October 2004, La Residencia, Castro, Urdiales, Cantabria, Spain

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EUROMECH Colloquia in 2005

460
Numerical Modelling of Concrete Cracking
Chairman: Professor G. Hofstetter, Institute for Structural Analysis and Strength of Materials University of Innsbruck, Technikerstrasse 13,
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Euromech contact person: Prof. F. Rammerstorfer
Date and location: 21–23 February 2005, Innsbruck, Austria

461
Vortex and Magnetohydrodynamics - Structure, Symmetry and Singularity
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462 Cancelled
Fluid Mechanical Stirring and Mixing

463
Size-dependent Mechanics of Materials
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DATE AND LOCATION: 13–16 June 2005, Groningen, The Netherlands

464
Wind energy
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DATE AND LOCATION: March 2005, Oldenburg, Germany

465
Hydrodynamics of Bubbly Flows
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DATE AND LOCATION: June, 2005, Lorenz Center Leiden, The Netherlands

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Computational and Experimental Mechanics of Advanced Materials 2005
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DATE AND LOCATION: June 2005, Loughborough, UK

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Turbulent Flow and Noise Generation
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DATE AND LOCATION: July 2005, Université de Provence, Marseille, France

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Multi-scale Modelling in the Mechanics of Solids

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DATE AND LOCATION: July 2005, St. Petersburg, Russia

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LES of Complex Flows

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DATE AND LOCATION: September 2005, Dresden, Germany

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Recent Development in Magnetic Fluid Research

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EUROMECH CONTACT PERSON: Prof. W. Schröder
DATE AND LOCATION: September 2005, Bremen, Germany

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Turbulent Convection in Passenger Compartments

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472

Microfluidics and Transfer

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Date and location: September 2005, Grenoble, France

473

Failure and Fracture of Composite Materials

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Co-chairman: Prof. P. T. de Castro, Departamento de Engenharia Mecânica e Gestão Industrial, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal
Euromech contact person: Prof. J. Ambrosio
Date and location: September 2005, Porto, Portugal

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Material Instabilities in Coupled Problems

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EUROMECH Colloquia in 2006

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Real-time Simulation and Virtual Reality Applications of Multibody Systems
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Co-chairman: Prof. W. Schiehlen, Institute B of Mechanics, University of Stuttgart, Germany
Euromech contact person: Prof. J. Ambrosio
Date and location: March 2006, Ferrol, Spain

477
Particle-laden Flow: from Geophysical to Kolmogorov Scales
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Euromech contact person: Prof. D. Lohse
Date and location: June 2006, University of Twente, The Netherlands

EUROMECH Colloquia Reports

EUROMECH Colloquium 442
Computer-Aided Optimization of Mechanical Systems
Chairpersons: Peter Eberhard, Dieter Bestle

EUROMECH Colloquium 442 was held at the University of Erlangen-Nuremberg, Germany, from 23–27 February 2003. There were 68 participants from 19 countries, mostly from Germany and Europe, but also from overseas. Grants from the German Research Council have been especially valuable for inviting several participants from Eastern Europe.

The scientific lectures were devoted to topics such as structural and material optimization, multibody systems, structural design, distributed modeling, design sensitivities, multicriteria optimization, identification, approximation and topology optimization. In 13 sessions 52 talks were given accompanied by active and interesting discussions which will initiate further investigations.

The colloquium showed in an impressive manner the ever increasing importance of optimization in many fields. Reaching from basic theoretical research over numerical approaches to methods for exciting practical applications, the talks reflected a fascinating width of topics being investigated by the contributing researchers. We had a nice blend of well-established leading scientists and young researchers who just recently joined the community with fresh innovative ideas. Three EUROMECH grants for young scientists were given to M. Silva, Portugal, H. Moeller, Denmark and C. Kraus, Germany, on the basis of recommendations by the Scientific Committee.

Beside the regular program, a special session, the Wolf Stadler Memorial Session, was established to honor the late Professor Wolfram Stadler from San Francisco State University, USA. He was a leading scientist in the field and participated actively in our scientific community for several decades. In four talks both personal statements and an estimate of the broad range of Wolf Stadler's contributions to the field have been provided by P. Eberhard, W. Schiehlen, K.-U. Bletzinger and J. Jahn.

Selected papers of the colloquium will be published in a special volume of the International Journal of Multibody System Dynamics. Guest editors will be the organizers D. Bestle and P. Eberhard.

Generous financial and material support contributed to the success of the colloquium. Financial aid was mainly spent to support participants from Eastern Europe and overseas which was highly appreciated. The help of the following sponsors is gratefully acknowledged:

European Mechanics Society EUROMECH
Deutsche Forschungsgemeinschaft DFG, Bonn
Friedrich-Alexander-University, Erlangen-Nuremberg
Brandenburg University of Technology, Cottbus
University of Stuttgart, Stuttgart
Bilz Vibration Technology, Leonberg
BMW AG, München
Siemens AG, Erlangen
Volkswagen AG, Wolfsburg

Finally, the organizers want to thank the members of the Scientific Committee for their contributions and helpful advice during the organization process and the local organizing committee for their devoted work.

EUROMECH Colloquium 443 & Lorentz-Center Workshop
High Rayleigh number convection
Chairpersons: Detlef Lohse, Friedrich Busse

One of the classical problems in fluid dynamics is Rayleigh-Bénard convection: a fluid heated from below and cooled from above.

About ten years ago, this problem had been considered to be basically solved. However, various experiments in the last decade have drastically changed our point of view on thermal convection. These experiments included high Rayleigh number measurements, large and small Prandtl number measurements, measurements on the Reynolds number, and measurements with rough boundary conditions.

The goal of EUROMECH Colloquium 443 and of the Workshop at the Lorentz-Center was to allow for an exchange of ideas on the recent developments in this field.

There were altogether about 50 participants and about 35 presentations, among them seven key-note lectures, namely Guenther Ahlers (Santa Barbara), Bernard Castaing (ENS Lyon), Siegfried Grossmann, (Marburg), Julian Hunt (London), K.R. Sreenivasan (Trieste), Penger Tong (Hongkong), and Roberto Verzicco (Bari). Most importantly, there was a lot of time for informal discussions between the participants who all were allocated offices equipped with computers and white-boards.

Recurring issues addressed in the talks and discussed were:

- *Flow visualization*
  The famous Chicago experiments on thermal convection in helium sup-

plied one-point measurements. Meanwhile, the field is much further. In Leiden PIV measurements of the full velocity field were presented, either giving the full view of the cell, or focusing on the boundary layer. Considerable progress was also, achieved with the Schlieren technique, which allows for a visualization of thermal structures in the boundary layers. The flow visualizations revealed that the flow geometry can be more complicated than a single convection roll: vortices can form in the corners, the convection roll can oscillate sidewards, or for aspect ratio 1/2 it can even split in two rolls. Besides the PIV experiments, also the numerical simulations now allow for very impressive flow visualizations, and wonderful movies were shown in Leiden, allowing for development of intuition on the flow.

- *Nu(Ra,Pr) and Re(Ra,Pr)*
  It became clear that the dependence of Nusselt and Reynolds numbers on Rayleigh and Prandtl numbers is more complicated than a simple power law. A new unifying theory of thermal convection, based on a decomposition of the kinetic and thermal energy dissipations, seems to be able to describe these more complicated dependences.

- *The aspect ratio dependence of the flow*
  Hitherto experiments have mainly focused on aspect ratio 1 or 1/2. However, there are strong indications that the flow pattern and in some regimes also the heat transfer strongly depends on the aspect ratio. Meanwhile, there are first theoretical predictions, and it became clear that future experiments will have to focus on a detailed exploration of the aspect ratio dependence.

- *Temperature boundary conditions at the top and at the bottom plate*
  Numerical simulations including the top and bottom plate were presented. Those simulations revealed that at plume detachment the bottom plate can locally cool down or the upper plate can locally heat up, resulting in non-constant temperature at the top and at the bottom. Depending on the material constants, this effect will set in sooner or later, but ultimately, i.e., for large enough Ra, it is unavoidable, and will lead to a lower heat flux as compared to the ideal case with constant temperature at top and bottom. Future experiments will have to take this effect into consideration. For very large Ra, constant temperature conditions may be unrealistic, and one may have to live with constant flux boundary conditions. Another task is to develop correction schemes for the non-constant boundary conditions, and to check whether they are working by doing experiments with fluids and plates with different heat conductivities.

- *Character of the kinetic boundary layer*
  Though older theories assume a turbulent boundary layer with a scaling of $\lambda_u \sim L/Re$ for its thickness, it became clear at the workshop that the Reynolds and thus Rayleigh number dependence is much weaker. At the sidewall it is consistent with the Prandtl-Blasius scaling $\lambda_u \sim L/\sqrt{Re}$, and at the top and bottom wall it is even weaker. Nonetheless, the flow in the kinetic boundary layer is of course clearly time dependent.

- *Role of plumes*
  During the workshop the role of the thermal plumes for the organization of the flow was again and again stressed. In spite of their importance, at least for small Prandtl number they do not seem to contribute much to the direct heat transfer. Future work will have to supply algorithms to distinguish between plumes and background in a systematic way.

- *Heat flux at $Ra > 10^{11}$* The discrepancy between the Oregon data and the Grenoble data for the Nusselt number beyond $Ra > 10^{11}$ could not be resolved. One suggestion was that the flow field and flow geometry inside the cell is different for these two experiments, but it is unclear why this should be.

From the above list it becomes clear that many questions are still far from being solved. The community agreed on meeting again in spring 2005, this time in Trieste.

We have heard from many participants that they really enjoyed the Meeting very much; several called it "the best Meeting they had ever participated in". In the last months I have seen various preprints which have emerged out of the Meeting, and the field really received a boost from these two weeks. We thank the Lorentz-Center and EUROMECH for making the Meeting possible, and for all the financial and organizational support.

EUROMECH Colloquium 446
High-order methods for the numerical simulation of vortical and turbulent flows
Chairpersons: Michael Schäfer, Patrick Bontoux

EUROMECH 446 was held from 10–11 March 2003, at the Lufthansa training center, close to Seeheim, Germany. There were 25 participants from 7 countries. There were 18 presentations in 8 sessions during the duration of the Colloquium.

The opening lecture was given by Prof. Egon Krause on "On Axial Flow in Slender Vortices" which pointed out interesting problems in the area.

An interesting discussion at the official dinner resulted in a small change in the lecture of one of the fathers of spectral methods Prof. David Gottlieb, who just after made a historical overview of the studies of the Gibbs' phenomenon, before the main part of his talk on "High Order Numerical Methods for Compressible Reactive Flow".

The main objective of the Colloquium was to bring together researchers with interest in theoretical, computational and applied aspects of high-order methods of vortical and turbulent flows.

The scientific program focused on :
- Compressible and reactive flows,
- Direct numerical simulation of turbulent flows and modeling,
- Spectral methods for flow instabilities,
- Numerical techniques,
- Coherent vortex simulations.

The talks were of a high scientific level and were actively discussed during the sessions. The location of the training center (it is surrounded by woods) and the integration of all the organizational aspects of the event in one place, resulted in an informal atmosphere which has led to a variety of discussions during coffee breaks, meals, cocktail and the official dinner.

All of the participants have been asked for a short paper, based on their talks that will be compiled in a special issue of Comptes Rendus de l'Académie des Sciences, Paris (published by Elsevier).

EUROMECH Colloquium 447
Interaction Phenomena in Turbulent Particle-Laden Flows
Chairpersons: M. Sommerfeld, Ü. Rudi, L. Zaichik

EUROMECH 447 has been held in Tallinn in the Estonian Energy Research Institute at Tallinn Technical University between 18–20 June 2003. 41 scientists from 11 countries participated it the colloquium.

The aim of the meeting was to exchange the ideas and results on interaction phenomena in turbulent particle-laden flows focusing on the physics of particle-turbulence interaction and turbulence modification, particle-wall and particle-particle interactions, particle coalescence and agglomeration, particle deposition, dispersion and clustering. Various approaches were presented at the colloquium to obtain either theoretical (numerical) or experimental results – the Eulerian and Lagrangian methods, statistical kinetic PDF models with one-point and two-point turbulence closures, spectral analysis, direct and large eddy simulations as well as LDA, PIV and other measurement techniques.

Two invited lectures and 23 oral presentations were presented in 3 technical sessions :
- Fundamentals,
- Numerical Calculations,
- Applications.

The first invited lecturer, Prof. B. Oesterle (University of Nancy, France), demonstrated the advantage of kinematic simulations for the prediction of the effect of preferential concentration in homogeneous isotropic turbulence flow as well as turbulence modulation. The following presentations of Dr. M. Bijard (Delft University, Netherland), PhD. student Kaufmann (European Centre for Research and Advanced Training in Sci. Comp., Toulouse, France) presented numerical results obtained by using DNS and Lagrangian tracking methods for the description of the effect of particles on turbulence modulation in case of fully developed channel flow and in homogeneous isotropic decaying turbulence, respectively. Using the same methods Prof. A. Soldati (University of Udine, Italy) gave a presentation on deposition phenomena occurring in vertical and horizontal channel flows for various particles. Clustering phenomena were reported by Dr. Portela (Delft University, Netherland) who calculated the formation of preferential concentration of particles in the near-wall region by using DNS and Lagrange tracking methods. Prof. L. Zaichik (Institute of High Temperature from Moscow, Russia) pointed out the significance of the turbophoretic force on the formation of particle clusters in homogeneous as well as in non-homogeneous turbulence using the PDF approach to model the dispersed phase. Dr. H. Soersen (Aalborg University, Denmark) reported numerical results on the motion of droplets of different size in a turbulent flow with zero mean velocity. In the report of Dr. A. Kartushinsky (Estonian Energy Research Institute, Tallinn, Estonia) a closure of the transport equation for the dispersed phase accounting for inter-particle collisions was presented and the numerical simulations were validated for a gas-solid particle flow in a horizontal channel. Experimental results on the behaviour of spherical and non-spherical particles at various loading ratios in a horizontal channel flow were presented by Prof. M. Sommerfeld (Martin-Luther-Universität Halle-Wittenberg, Germany. PhD student C. Losenno presented experimental results on freely falling crushed and spherical glass beads obtained by LDA measurement techniques.

A second invited lecturer Dr. E. Helland (ABB Turbo Systems Ltd, Switzerland) reported numerical simulations of clustering phenomena observed in fluidized bed systems. The calculations were done by DNS and a Lagrangian particle tracking method and results were extracted regarding the cluster formation in various regions of the circulating fluidized bed. Numerical simulations of the scattering of non-spherical particles and the resulting surface erosion were presented by Prof. Yu. Tsirkunov (Baltic State Technical University, Saint-Petersburg, Russia). In the report of Ph.D student C.-A. Ho (Martin-

Luther-Universität Halle-Wittenberg, Germany) numerical simulations of the collision of small particles with a large collector were presented based on solving the 3D Navier-Stokes equations in connection with the Lagrangian approach for the small particles. Prof. O. Simonin (Institute of Fluid Mechanics, France) presented results on the interaction of a slab of particles injected at high velocity into isotropic decaying turbulence. It was shown that turbulence damping occurred in the core of the slab and an enhancement was observed in the periphery of the slab induced by high mean gas velocity gradient. Numerical calculations, of heat and mass-transfer due to the evaporation process occurring in gas-droplet two-phase systems were presented by Ph.D. student M. Pakhomov (Kutateladze, Institute of Thermophysics, Novosibirsk, Russia). In the report of Dr. D. Graham (University of Plymouth, UK) a bootstrapping method based on resampling the original data (particle statistics) was suggested to avoid repeated computations. The particles' stabilizing behaviour in swirling vortex flow was studied by an uncoupled Lagrangian approach by Dr. Kaplanski (Estonian Energy Research Institute, Tallinn, Estonia). PhD student E. Kumzerova (Ioffe Physical-Technical Institute, Saint-Petersburg, Russia) reported the numerical investigation of bubble nucleation under rapid liquid pressure drop. PhD student K. Savolinen (Tampere University of Technology, Finland) presented experimental results of particle-turbulent interaction in upward gas-solid particle pipe flow. Prof. Varaksin (Institute of High Temperature from Moscow, Russia) showed experimental measurements in downward turbulent gas-solid pipe flow retrieving the particle velocity fluctuations of collisional origin. Dr. A. Kartushinsky (Estonian Energy Research Institute, Tallinn, Estonia) showed some experimental results of turbulence modulation in a downward directed wind-tunnel flow and its dependence on the loading ratio and the magnitudes of the slip velocity. Experimental investigations of bubbles behaviour in a container flow with vortex-breakdown, was presented by Dr. 1. Naumov (Kutateladze Institute of Thermophysics, Novosibirsk, Russia). A model for diesel fuel spray penetration with the consideration of the effects of droplet evaporation and break-up together with the air entrainment, was presented by Prof. S. Sazin (University of Brighton, UK). Finally, a new sampling method for the measurement of the concentration of pollutants in sewage water flows was presented by Dr. F. Larrarte (Laboratoire Central des Ponts et Chaussées, France). The discussion revealed the importance of a detailed modelling of particle-turbulence, particle-particle and particle-wall interaction processes for a reliable numerical prediction of particle-laden turbulent flows using engineering type of approaches. Further direct numerical simulations (DNS) as well as detailed experimental studies are needed to advance the basic understanding of these elementary processes and to improve the models. These developments will allow a more reliable application of numerical methods for optimisation of industrial processes.

Part of the results presented at the colloquium can be published in the Proceedings of the Estonian Academy of Sciences.

A fellowship of 200 EURO was given to three young (under 35) Russian Scientists: Mrs Ekaterina Kumzerova, Dr Igor Naumov, and Mr Maxim Pakhomov.

EUROMECH Colloquium 451
Sea Wave Bottom Boundary Layer
Chairpersons: Enrico Foti, Jorgen Fredsøe

The colloquium was held in Taormina (Italy) from the 26–29 October 2003. The aim of the meeting was to provide opportunities for scientists to meet and to discuss their current research on sea wave bottom boundary layers.

The topic of the Colloquium was treated from three different viewpoints: field investigations, experimental investigations and theoretical and numerical modelling.

Three invited lecturers introduced the three day meeting by giving talks on the following topics:

- "*Field investigation of wave boundary layer*" given by Prof. John Trowbridge, from Woods Hole Institute of Oceanography (USA) on the first day;
- "*Experimental investigation of wave boundary layer*" given by Prof. B. Mutlu Sumer, from Technical University of Denmark (Denmark) on the second day;
- "*Theoretical and numerical investigation of the sea wave boundary layer*" given by Prof. Giovanna Vittori from University of Genoa (Italy) on the last day.

The time allowed for each presentation was 20 minutes followed by 5–10 minutes of discussion, during which several suggestions were given by the audience. In order to enhance the possibility of discussion, the question time was never curtailed, even if out of schedule. It is worth pointing out that the presence of a large number of young scientists stimulated quite a lot of discussions.

A scholarship of 200 euros, provided by EUROMECH was given as financial support for participation in the Colloquium to the following three young scientists: D.O. Lambkin, T.O. Robinson, and J. van der Werf.

Specific contributions and discussions covered quite extensively the interaction of the flow with the sea bottom, also in the presence of both small and large scale bedforms.

Great attention was devoted to the study of wall turbulence. From the experimental point of view, particularly by using flow visualization methods, quantitative measurements of the velocity profiles were presented. Many presentations were also given on the mechanism of ripple formation and on turbulence induced by a rippled bed. Very detailed investigations by means of DNS techniques have been carried; such investigations showed good performances particularly in representing the turbulence within the boundary layer. Also the topic of wave-current interaction was addressed by several scientists.

At the end of the Colloquium a final concluding discussion, which involved all the scientists, was organized. It has been observed that, despite the importance of experimental campaigns, both in the field and in the laboratory, among 31 contributions only 1 presented results coming from a field investigation, and only 8 concerned experimental works. Thus the community should promote with more strength field investigations notwithstanding all the associated economic and logistic problems. Indeed, field data are still insufficient, particularly in the presence of sandy bedforms.

Moreover, it was recognized that a very detailed flow modeling is now available, whereas, at present, only a very limited understanding of the processes of sediment-flow and grain-grain interactions has been achieved.

Few open questions related to experimental investigations remain still open. Indeed there is a lack of laboratory data for the fully turbulent regime, which is a condition closer to the field, particularly for the wave plus current case.

Finally, even though the numerical modeling allows a very detailed description of the flow, still a lot of work needs to be done on flow-sediment interactions.

Objectives of the European Mechanics Society

The Society is an international, non-governmental, non-profit, scientific organization, founded in 1993. The objective of the Society is to engage in all activities intended to promote the development of mechanics in Europe as a branch of science and engineering. Mechanics deals with the motion, flow and deformation of matter, be it fluid or solid, under the action of applied forces, and with any associated phenomena. The Society is governed by a Council composed of elected and co-opted members.

Activities within the field of mechanics range from fundamental research on the behaviour of fluids and solids to applied research in engineering. The approaches used comprise theoretical, analytical, computational and experimental methods. The Society shall be guided by the tradition of free international scientific co-operation developed in EUROMECH Colloquia.

In particular, the Society will pursue this objective through

- the organization of European meetings on subjects within the entire field of mechanics;
- the establishment of links between persons and organizations including industry engaged in scientific work in mechanics and in related sciences;
- the gathering and dissemination of information on all matters related to mechanics;
- the development of standards for education in mechanics and in related sciences throughout Europe.

These activities, which transcend national boundaries, are to complement national activities.

The Society welcomes to membership in the Society all those who are interested in the advancement and diffusion of mechanics. It also bestows honorary membership, prizes and awards to recognize scientists who have made exceptionally important and distinguished contributions.

Members may take advantage of benefits such as reduced registration fees for our meetings, a reduced subscription to the European Journal of Mechanics, information on meetings, job offers and other matters in mechanics. Less tangibly but perhaps even more importantly, membership provides an opportunity for professional identification and for helping to shape the future of our science in Europe and make it attractive to young people.

Important Information for Chairpersons of EUROMECH Colloquia

- EUROMECH Colloquia are organised under the auspices of the EUROMECH Council. The Chairpersons (i.e. Organisers) of Colloquia are appointed by the Council and are fully responsible for the planning and running of their Colloquia.
- EUROMECH Colloquia should be specialised in content, small in size and informal in character. Participation in Colloquia is on the invitation of the Chairpersons. Number of participants: 40–60; duration: 3–4 days; no parallel sessions!
- The cost and, thus, the registration fee should be kept low. The registration fee for participants who are not members of EUROMECH must include 32 Euros. This is additional to the amount which the Chairpersons charge in order to cover local costs, and is to be transferred to the Treasurer of EUROMECH after the colloquium. The two categories of registration fee (non-members, members) should be indicated as follows: (I) the full registration fee and (II) the reduced registration fee (32 Euros lower).

Chairpersons' actions when preparing the Colloquia

1. Decide on definite title, date and location for the Colloquium.
2. Write an approximately 100-word description (a Word Document or e-mail would be appreciated) of the intended scope and topics. Send it as soon as possible to the Secretary General of EUROMECH.
3. Prepare an Announcement for the Colloquium, with a description of the intended scope and the topics to be discussed, and send it to prospective participants, to anyone who could help to enrol participants, and to the Secretary General. Use the notation 'EUROMECH Colloquium ###' in all written material. Ask the prospective participants to provide a summary of the work they wish to report (unfinished work is welcome).
4. Invite the selected participants. Prepare the programme of the Colloquium. Collect the summaries of the contributions into a booklet for distribution to participants before or at the meeting.
5. Provide information material about EUROMECH to the participants and encourage them to become members of EUROMECH.
6. Stay in contact with your EUROMECH contact person (assigned member of the EUROMECH Council).

7. EUROMECH will provide up to 600 EUR for support of young scientists participating in the Colloquium. This money should be reserved from the income from the registration fees. The amount of money used for such fellowships can be deducted from the amount to be sent to the Treasurer (see item 3 below). The recipients of such fellowships must be identified on the Final Report form (see item 1 below).

8. The EUROMECH Council cannot be held responsible for any financial deficit resulting from running the Colloquium.

Chairpersons' actions within a month after the Colloquium is finished

1. Prepare a brief final report on the Colloquium using the Final Report form (to be downloaded from the EUROMECH website) and send it also as a Word Document or by e-mail.

2. Compile a set of the documents prepared for the Colloquium and send it together with the Final Report to the Secretary General.

3. Contact the Treasurer of EUROMECH and send him the EUROMECH component of the registration fee for non-members (32 Euros each).
