compared with the sound wave, is not enough researched in past papers. This paper, therefore, aims to clear the characteristic of multiple pressure wave, especially the attenuation and directivity of that wave, and the relation between the pulsating pressure wave and multiple pressure wave by the experiment and numerical analysis using TVD method. In the experiment, the spherical valve is used for generation of the pulsating pressure wave in the propagation tube and the tube diameter are D=19 mm , 35mm The metal spherical with diameter 25mm is rotated by the motor and the pulsating pressure wave is formed in the propagation tube. In the numerical calculation, the x-y cylindrical coordinates system was considered. The basic equation is the compressible unsteady axisymmetric Euler's equation and was solved by the TVD method.

The results are as follows. (1) The attenuation and directivity of the multiple pressure wave are clearly observed and this characteristic corresponds to that of the simple impulsive wave caused by the weak shock wave or the compression wave. (2) The over pressure of the multiple pressure wave, which is non-dimensionalized by the over pressure of the pulsating pressure wave propagated in the tube Δp^*, Δpr, max/Δp^* decreases with an increasing of the distance from an open end of a tube r/D and the degree from a tube axis θ, caused by the attenuation and directivity. The directivity for axis direction is a large compared with the radial direction. (3) The over pressure of the multiple pressure wave Δpr,max/Δp^* decreases with an increasing of the length of the pulsating pressure wave L/D and the strength of that wave strongly depends on the length of the pulsating pressure wave. (4) The degree of attenuation of the multiple pressure wave approximately corresponds to the result obtained by the analysis for the simple impulsive wave and it is possible to estimate the attenuation of the multiple pressure wave using this analysis for simple impulsive wave.

10:40-12:00 (Room102)

Biofluid Dynamics (II)

Session Chair : Prof. M. S. Saidi, Isfahan Univ of Tech/Iran

W-2B-1. LOAD SUPPORTED BY FLOATING ELASTIC SHEETS

K. J. PARK, *Seoul National University, Korea*, D.-G. LEE, *Seoul National University, Korea*, H.-Y. KIM, *Seoul National University, Korea,* Water striders can float and move on water by effective use of surface tension. In particular, their one superhydrophobic leg is known to be able to support much heavier load than their body weight without sinking. The legs of water striders and their biomimetic robots are long and thin so that they are flexible. We focus on how the legs in static equilibrium are deformed by hydrostatic pressure and surface tension. As a model for the legs, we theoretically and experimentally study the deformation of floating flexible sheets. To predict the deformation we use a theory of elasticity under assumption that the transverse deflection is very small compared to the sheet length. The deflection is determined with the boundary conditions including the surface tension effects of water-air interfaces, whose profiles are obtained by using the Young-Laplace equation. The equilibrium shapes of the sheets are experimentally measured. We find that the descent distance of the edge clamped to the load is different from the descent distance of the tip free edge due to the deflection. The experimental data are compared with the predictions and it shows that they are in good agreement. Finally, by calculation of the shear force at the clamped edge, we show that flexible sheets can sustain heavier load than rigid sheets. In addition, we find out that one important parameter, which determines the deformation and load capacity, is the elastocapillary length.

W-2B-2. DETACHMENT OF SEED FROM A DANDELION CLOCK

M. HASEGAWA, *Department of Mechanical Engineering, Toyo University, Japan,* O. MOCHIZUKI, *Department of System Robotics, Toyo University, Japan,* We discussed aerodynamic reasons why the seeds detached from the portion of the dandelion clock first in a uniform flow through visualization experiments of a porous sphere. The first detachment position of the seeds from the peicarp was in a range from 33 degrees to 106 degrees measured from a front stagnation point. The flight performance of the wind-borne dandelion seeds was investigated through a free fall experiment in a box without external turbulence. We used the high-speed CCD camera to measure the speed of a free falling seed The seed consists of a pappus, stalk and achene. Effects of numbers of thin feathered structures of the pappus on the final speed were observed to know the drag coefficient of the structure. To know which seeds start to fly, visualization experiment of the seeds detaching from a pericarp of a dandelion clock was carried out in a uniform flow with various flow-speeds. We used the CCD camera to record the first detachment portion. The flow penetrates the dandelion clock. The dandelion clock was supposed to be a porous sphere. The drag force, D, was measured by a thin plate pasted strain gages which was installed the porous sphere. Streak lines were observed by ink. The definition of the angle measured from the front stagnation point of the dandelion clock in a uniform flow and forces acting on a seed. The first portion where the seed detached was found to be in a range from 33 degrees to 106 degrees. The relation between the final speed of a seed and the number of thin feathered-structure of the pappus was found that the final speed is found to be inversely proportional to a root. This means that the total drag of the pappus is able to be expressed by linear summation of drag-values of individual thin feathered-structures. Thus, the forces acting on the seed are easy to estimate if the low Reynolds number flow around the thin feathered-structure is known. Interval between vortices behind the porous sphere is smaller than that behind the solid sphere. The drag coefficient of the porous sphere was smaller than that of the solid one. The close-up view of the flow ejecting from holes at rear side of the porous sphere, this ejection was intermittent but was synchronized with shedding vortices. The back flow was reached at = 105 degrees. This should affect the outer flow along the surface. We estimated force acting on a thin-feathered structure of the pappus and observed the first portion of the detachment of seeds from the dandelion clock. The force to lift the seed was expressed by the individual force times the number of the thin feathered-structure. The first portion of the detachment was the front area centered at 70 degrees from the front stagnation point of the dandelion clock.

W-2B-3. THREE-DIMENSIONAL SIMULATION OF A FLAPPING FLAG IN A UNIFORM FLOW BY THE IMMERSED BOUNDARY METHOD

W.-X. HUANG, H. J. SUNG, *KAIST, Korea,* We proposed an immersed boundary (IB) method for three-dimensional simulation of flapping flags in a uniform flow. In the present method, a direct numerical scheme is developed to calculate the flag motion, with the elastic force treated implicitly, while the fluid motion defined on an Eulerian grid is calculated using an efficient Navier-Stokes solver. An additional momentum forcing is formulated from the flag motion equation in a way similar to the direct-forcing IB formulation and acts as the interaction force between the flag and its ambient fluid. When the gravity force is excluded, the flag flaps almost uniformly along the spanwise direction, with slight asymmetry about the centerline, which is attributed to the hyperbolic property of the flag motion equation. An O-shape vortical structure is shedding from the trailing edge, connected by a Ω-shape structure shedding from both side edges. After including the gravity force, the sagging-down of the flag and the rolling-up of the upper-corner deform the vortical structures. The Strouhal number defined in terms of the flapping amplitude increases slightly with increasing the Reynolds number and is between 0.16 and 0.22, consistent with the general value of a flying or swimming animal. The onset of regular flapping is found to be subcritical and the bistability region is narrow in our simulations. A linear stability analysis for a flag of infinite spanwise width shows that the most unstable mode corresponds to the flag uniform in the spanwise direction. The aspect ratio effect was analyzed through numerical simulations and the theoretical results were compared with the numerical results and those from previous studies. Nodeless flapping and flapping with an imperfect node were observed in the present simulations.

W-2B-4. LIFT PRODUCTION OF A TWO-LINK FLAPPER IN A VISCOUS FLUID

J. BAI, *The State Key Laboratory of Nonlinear Mechanics, IMECH, CAS, China*, X. ZHANG, *The State Key Laboratory of Nonlinear Mechanics, IMECH, CAS, China*, A recent experimental study by Childress et al. (Physics of Fluids (2006) 18, 117103) shows that small flexible bodies made of stiffened tissue paper can hover in an oscillating air flow. In this paper, a numerical simulation is conducted to investigate the lift production mechanism of such ‘flapper’. The flapper is modeled as two articulated rigid plates joined by one hinge. Instead of an oscillating flow, a harmonic motion of the articulated body in the vertical direction is assumed. In order to treat the moving boundaries associated with this problem, a flow solver based on the Immersed Boundary (IB) method is developed. In this approach, the partial differential equations are solved on a Cartesian grid which is not body-fitted. Since no re-meshing is needed, IB method exhibits its advantages in simulating flows with moving boundaries. For the details of the IB method used in this study, please refer to the paper by Takeno Kajishima.[3] The state of motion of the flapper is determined by solving the Euler-Lagrange equations. Numerical results indicate that the flapping of the articulated body can produce lift with certain combinations of amplitude and frequency. In this paper, instead of an oscillating flow, the flapper is oscillating in a fluid which is considered to be incompressible and viscous. The hinge that links the two elements is modeled by a torsion spring with positive stiffness. While the point which connects the two elements is oscillating along the vertical direction, the vibration function is