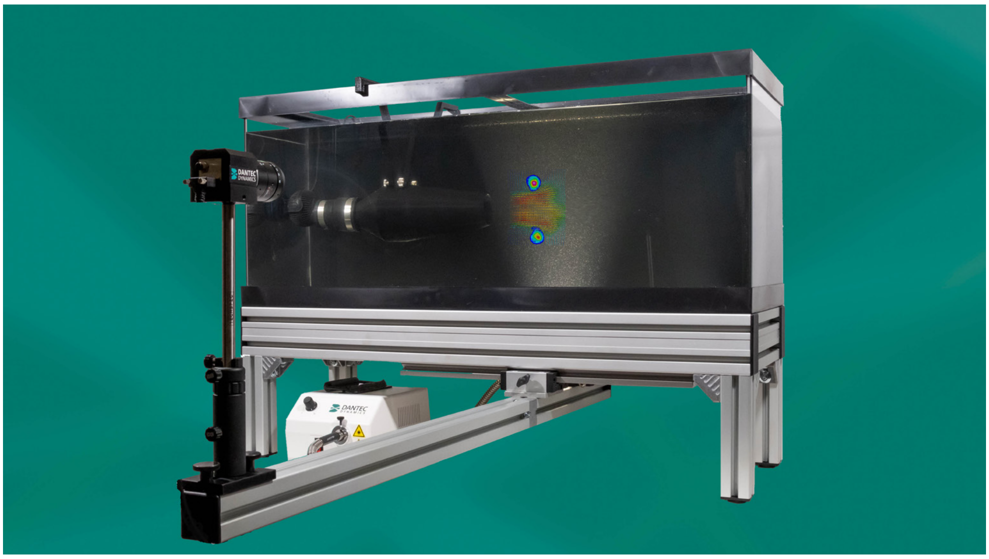
SOLUTION SHEET

EduPIV

LED-Based Educational Particle Image Velocimetry System



EduPIV - turnkey PIV system for educational use

Turnkey PIV system for educational use

Particle Imaging Velocimetry (PIV) systems allow for non-intrusive optical measurements of velocity fields in flows. Historically, PIV has been out of reach for most educational laboratories due to cost and laser-safety concerns. The EduPIV system offers a safe, affordable and turnkey solution for introducing students to this powerful technique. This system employs an LED-based illumination source which is safe and easy to operate while combining excellent reliability and performance. Complete with all necessary hardware, software and table-top flow experiment, the EduPIV system can carry out simple PIV experiments and demonstrations without the need for any additional equipment. For data acquisition and flow analysis, the system comes with the full-featured version of DynamicStudio - the most comprehensive and powerful imaging software for optical velocity measurements.

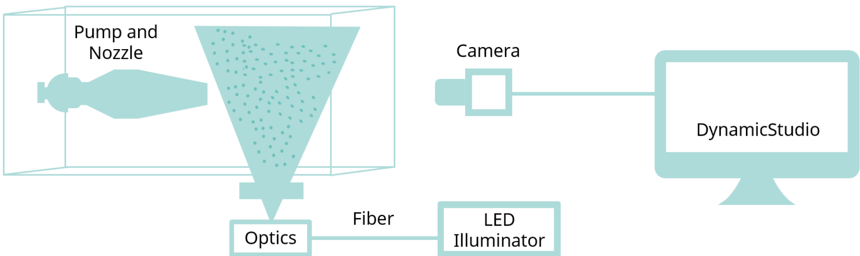
Key benefits

- Time resolved PIV measurements for fluid mechanics laboratory courses
- Student training - prepare students for PIV research during and after university
- Safe operation with LED illumination – no lasers.
- Full-featured DynamicStudio software to provide students with real-world PIV experience
- Complete flow-loop and experiment with guided instructional video
- Simple, flexible flow loop design; easy to add student-created experiments
- Quick-swap 3D-printed nozzle

The EduPIV solution in brief

Particle Image Velocimetry (PIV) is a non-intrusive optical measurement technique for research and diagnostics into flow, turbulence, microfluidics, spray atomization and combustion processes. A fluid is seeded with small entrained particles which follow the fluid's motion. The particles are illuminated and captured via camera with fluid motion subsequently analyzed using PIV software. Standard 2D2C PIV (2 Dimensions, 2 Components) measures two velocity components in a plane using a single camera and typically consists of: a camera, a laser with some beam guiding components, light sheet optics, a synchronizer and a PC for data acquisition, storage and analysis. For the EduPIV system, an LED illumination source and fiber optics are used rather than a laser, and the image timing is controlled entirely by camera settings in the DynamicStudio software. The configuration of the system makes it safe and simple to operate, allowing students to focus on learning measurement principles rather than operating complex hardware.

A complete experimental setup and measurement system is included to provide a turnkey solution for PIV instruction. The basis of the flow setup is a water tank experiment (flow loop) with a variable pump and nozzle. The nozzle produces a water jet which allows for a number of tests to be carried out and the flow loop can be easily reconfigured for additional tests. Polyamide spheres are used for seeding the jet flow, and our FlowSense USB 2M-165 camera captures the particle motion. The images are analyzed using DynamicStudio to provide global velocity maps, turbulence statistics, scalar analysis, temporal/spectral evaluation and flow visualization.



EduPIV Flow Loop Experiment

The flow loop consists of a water tank on a table-top aluminum frame with a sliding arm mount for the camera and light sheet optics. The LED and sheet optics illuminate the measurement plane and the sliding arm moves the camera and light sheet together for imaging different areas of the flow. The included pump and nozzle provide a jet flow with variable output controlled by an electronic controller. The water jet can be operated in the following modes:

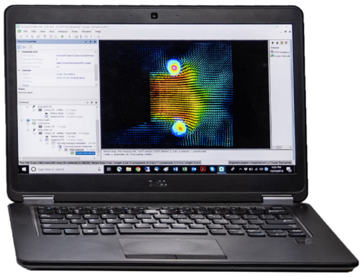
Steady Flow: This is the first and most basic flow used to teach students the fundamentals of the PIV method. It consists of a quasi-steady, turbulent jet flow. Providing a simple (primarily) unidirectional flow allows students to start by focusing on the PIV method rather than the flow complications. Here, students learn the basic parameters for carrying out PIV experiments: timing, seeding, camera setup and illumination basics. Flow speed is variable up to approximately 50 cm/s with the supplied nozzle. Higher/lower velocities can be achieved using different nozzles.

Periodic Flow: The jet velocity fluctuates periodically to create a dynamic jet flow. This allows students to do temporal, spectral and modal analysis. More consideration of PIV parameters is introduced to account for the larger variations in velocity.

Pulsed Flow: The pump is pulsed on and off to create shedding ring vortices. This allows the students to visualize dynamic modes and identify vortex shedding frequencies and vortex identification techniques.

Random Flow: As the name suggests, this mode creates random output. This can be used for long dynamic stability tests and is recommended for advanced studies in conjunction with other laboratory instruments.

The EduPIV flow loop setup is designed for maximum flexibility. While the introductory flow tests analyze the free-stream jet, it can be used as-is for small objects such as airfoils placed into the stream. Additionally, the nozzle can be exchanged for different types or sizes which can easily be 3D-printed by students for different measurement tests.

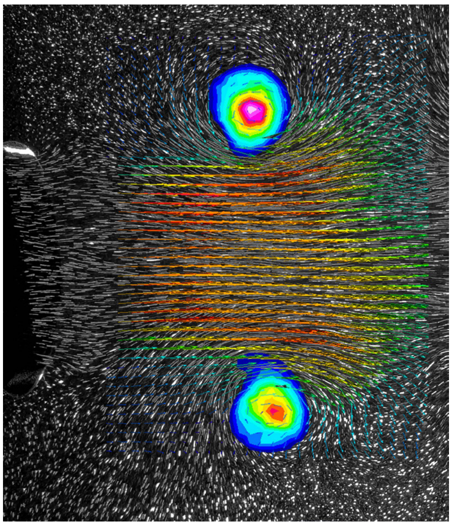


DynamicStudio software for the EduPIV system can be run from a laptop with USB 3.0.

DynamicStudio

The DynamicStudio software links acquisition, data processing and results analysis together in a powerful user interface. To calculate the velocity fields from acquired raw images and analyze the results, the DynamicStudio Base package and add-on for 2D2C PIV analysis are used.
The EduPIV system includes our full-featured software allowing students to get real-world experience with the most advanced processing techniques available. With data acquisition and analysis performed in the same software, there is no need to move data around. Dedicated analysis routines and customized analysis sequences allow for quick investigation and visualization of results. The software is very easy to use and includes extensive data exchange features (e.g. MATLAB) for more advanced student projects and reports.

For further details on the software performance, please consult separate data sheet on the “DynamicStudio Software”.



Particle motion from vortex ring with overlaid instantaneous PIV vector and scalar data. Vortex core identification based on 2nd invariant Q-values.

FlowSense USB 2M-165

Camera and lens

The FlowSense USB 2M-165 camera offers the ideal solution when it comes to performance and ease of use. With its USB interface, the camera can be used with a USB 3.0 PC or laptop without the need for frame grabbers or other hardware. At 1920 x 1200 pixels, the CMOS sensor is capable of 165 frames per second and higher frame rates with reduced region of interest. The low-distortion 35mm, f/2.8, c-mount lens provides the optimal magnification and field-of-view for the EduPIV flow loop. The lens is compact and sturdy with simple operation and lockable settings to help students maintain settings after calibration.

The camera is mounted to a sliding arm on the flow loop to quickly and easily move the area of measurement within the tank.

LED illumination and sheet optics

To provide safe and reliable illumination, an LED light source is used. The 150W illuminator provides the intensity needed for the short exposure times used in PIV measurements. The output of the illuminator is coupled to a multi-mode fiber optic bundle. On the output end of the fiber bundle, the fibers are arranged in a row to create a line of light. The line is focused with a rod lens in order to form a sheet of light. The focal point (or saddle point) of the light sheet can easily be adjusted by moving the rod lens up and down. The compact line light and rod lens are affixed to the same sliding arm as the camera so they move together to measure in different areas of the tank.

Pump, Controller and Nozzle

The pump is simple to operate and mounts in the tank via a magnetic base. The pump is connected to the 3D-printed nozzle via a rubber boot which allows for quick and easy removal or replacement. With this flexible design, students can design and print their own nozzles or conditioners to create and measure various flows. The pump controller allows for quick manual adjustments and can be adapted for external control for more complex experiments. The nozzle has a 5 cm diameter outlet and provides a flat jet profile.

LED fiberoptic guide and sheet optics.

Pump and controller.

3D-printed nozzle.

Technical specifications

Component	Model	Details
Software	DynamicStudio	Base package 2D PIV Complete Image Processing Library MATLAB Link
Camera	FlowSense USB 2M-165	165 frames per second 1920 x 1200 pixels USB 3.0 Interface
Lens	35mm Low-Distortion Lens	f/2.8 – f/16 aperture 35mm focal length c-mount lockable focus and aperture
LED	EduPIV LED	150 W Illumination 110/220V Input
Light Sheet Optics	Fiber Light	Fiber-optic line light guide Adjustable Focus Rod Lens 35˚ divergence angle 7.6 cm sheet width at aperture 4mm minimum sheet thickness
Pump		0.2 – 0.5 l/s 12 VDC
Nozzle		Jet diameter at exit: 5 cm Flow range: 2 - 5 cm/s
Flow Loop		92 x 69 x 32 cm 140 liters

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