

1st QTB PBR Hack'a'thing

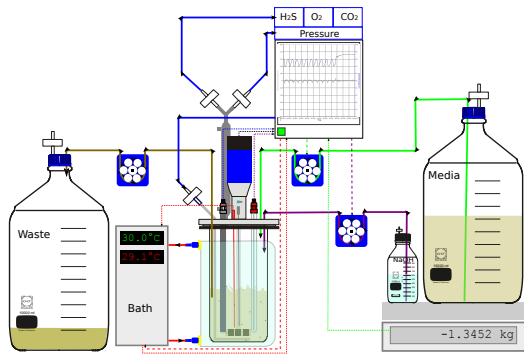
Soldering for and by beginners.

March 2–4, 2016

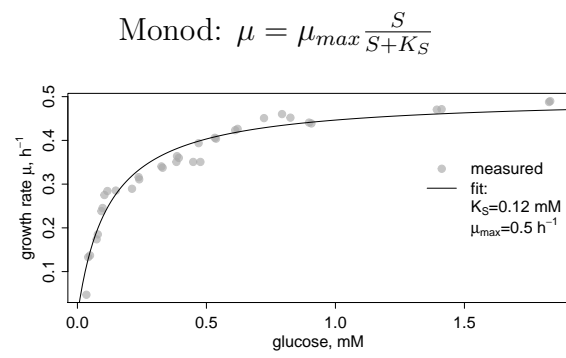
Contents

1	PBR Hack'a'thing Projects	2
1.1	Gas Flux: Gas'o'meter	3
1.2	Light Flux: Spectrometer	4
1.3	Liquid Flux: Continuous Culture & Turbidostat	5
1.4	The Server	6
1.5	Heat Flux: Water Bath Thermostat	7
1.6	The Kaiten Eppi: Automated Sampling Device	8
1.7	Single Cell Biology: Microfluidic Device	9
2	Program	10
2.1	Day 1 <12:00 : Building Bioreactors	10
2.2	Day 1 >13:00 : Hack'a'thing I	10
2.3	Day 2 : Hack'a'thing II	10
2.4	Day 3 : Hack'a'thing III	10
3	Outlook: 2nd QTB PBR Hack'a'thing	11
3.1	<i>Growth Dynamics</i> : Photobioreactors in Research	11
3.2	<i>Single Cell Dynamics</i> : Microfluidic Devices	11
3.3	<i>Omics</i> : Sterile and Automated Sampling Devices	11

1 PBR Hack'a'thing Projects



(a) Dougie's Reactor



(b) Snoep *et al.* 2009

Figure 1: Bioreactors

1.1 Gas Flux: Gas 'o'meter

Project: Extend existing setup, co2meter's O₂ and CO₂ sensors with Sainsmart's Arduino Mega+Touch screen

1. **code** sensor calibration routines via touch-screen (use PSI gas mixing system)
2. **build** water trap, tubing path from reactor, and casing for sensors and Arduino; **build** improved gassing system (glas blowers!) to allow lower flow
3. **build** & **code** interface to Aalborg XFM digital mass flow meter: connect the Aalborg's RS 485 interface to Arduino hardware serial Tx3/Rx3, and Ground
4. **build** & **code** valve control to measure several reactors; connect via Arduino software serial connections; perhaps attach to PSI Multicultivator

Ressources:

- Sensor manuals in manuals/offgas/ at <https://git.hhu.de/machne/PSIControl:Manual-CM-0201-UV-Flux-Oxygen.pdf>, [Manual-GSS-Sensors.pdf](#), and [A_XFM_Manual_TD0701M\[...\].pdf](#)
- Code in offgas/arduino/ at <https://git.hhu.de/machne/PSIControl>

Materials:

- Existing setup: **available**
- Aalborg XFM, with RS 485 interface: **available**
- Valve system for gas tubing, controllable *via* serial interface: **obtain**

1.2 Light Flux: Spectrometer

Project: Simple spectrometric measuring tool based on AvaSpec-Mini2048l-V25

1. Basic: Connect to Raspberry Pi, using drivers provides by Avantes; **code** simple interface with display and/or recording functions
2. Advanced: use LED for absorbance, reflectance, or fluorescence measurements; **build** light paths and perhaps a reactor probe for online recording

Ressources:

- AvaSpec-Mini data sheet in manuals/spectrometer/ at <https://git.hhu.de/machne/PSIControl>

Materials:

- AvaSpec-Mini2048l-V25, Minispectrometer: **available**
Mini spectrometer, 2048 Large pixels, grating-MN0600-0.50 (350-885nm), OSC, 25µm slit, USB2 interface, AvaSoft-Basic
- Fiber optic cables, VIS/NIR: 1 m, 200 µm VIS/NIR and 1m, 600 µm: **available**
SMA terminations, metal protection sleeves
- Raspberry Pi Version 1: **obtain**
- LED system: use PSI LEDs or **obtain**
- Reactor probe: **build** together with fine mechanics or glas blowers



(a) AvaSpec-Mini 2048

setup sketch here
(b)

Figure 2: Spectrometer Module

1.3 Liquid Flux: Continuous Culture & Turbidostat

Project: build a module consisting of media and waste bottles, a reactor vessel, peristaltic pump(s), and a scale; pump and scale are controlled *via* serial interfaces from an Arduino+Touchscreen. The flow rate is controlled *via* the pump motor speed and recorded *via* the scale; the flow rate is recorded or can be set after a setup-specific (tubing) calibration routine

1. **build** a simple reactor vessel (Schott bottles) with liquid media flow, from media bottles through reactor vessel and out to waste bottle
2. **code**: calibration routine for the weight sensor module
3. **code**: analog control of peristaltic motor speed and recording of weight loss and/or gain to record mass flow (g/min)
4. **code**: routine to calibrate pump speed to weight loss/gain for a specific setup; store calibration on SD card, which allows to also set pump speed in g/min, or if provided with a culture volume, as culture dilution rate (h^{-1})
5. **build** & **code**: combine with 1.2 to make turbidostatic control
6. **build**: add gassing system of project 1.1 to make a first simple bioreactor

Ressources:

- Arduino tutorials for Adafruit peristaltic pump and general DC motor control and Adafruit motor shield
- Arduino library for Elecrow weight sensor kit 3 kg
- HX711 24-Bit Analog-to-Digital Converter (ADC) for Weigh Scales

Materials:

- Bottles, screw caps with inlet/outlet openings, and tubing: **available** & **obtain!**
- Scale - **obtain**
fancy: Mettler Toledo, PBK785-3XS/f
cheap: Elecrow Weight Sensor kit 3kg for Arduino
- Peristaltic pumps - **obtain**
fancy: Longer Pump LP-BT100-2J, DG-2(10)
cheap: Ismatec Ecoline VC-MS/CA4-12
cheaper: Welco WPM or cheapest: Adafruit
- Sainsmart Arduino Mega + Touchscreen - **obtain**

1.4 The Server

Project: a master software running on a (detachable) linux desktop that synchronizes and speaks via a common interface to all Arduino and Raspberry Pi modules; the modules themselves can interpret get, set and act impulses (use arguments only when absolutely necessary).

During an initialization the server may inquire what an attached module provides (*via* data IDs and SI units, meaningful time resolution) and handle it automatically.

Variable higher order control or processing logics can be built using defined data and control IDs.

1. **build** combine of gas (1.1), liquid (1.3) and light (1.2) modules into a bioreactor
2. **code**: master program to synchronize and record data from the three modules
3. **code**: combine e.g. 1.2 & 1.3 to implement turbidostat control

Materials:

- `setTime(time_t t)`: sets the current master time to all modules
- `get(..., time_t t)`: get all values, currently available (with a time stamp), or from a previous time t
- `act(..., time_t t)`: act (switch on and off, set to a specific value), now or at future time t

1.5 Heat Flux: Water Bath Thermostat

Project: build a water bath for growth vessels, control T, read-out energy required for maintaining constant T and estimate the amount of heat withdrawn or administered

1.

Materials:

- Jacketed reactor vessel: **build** or **obtain**
- Julabo water bath, e.g. F25-ME
- Arduino and/or Raspberry Pi

1.6 The Kaiten Eppi: Automated Sampling Device

Projects: build sterile and automated sampling device; using a controllable syringe pump, sampling into the Kaiten Eppi (automated: pump sample into tubes, potentially pre-filled with chemicals, vortex, and transport them into liquid N₂ or other storage containers)

Materials:

- Sterile sampling device by HHU glas blowers: **available**
- Syringe pump: **obtain**
- Kaiten Eppi: **build**
- Sainsmart Arduino Mega & Touchscreen: **obtain**

1.7 Single Cell Biology: Microfluidic Device

Project: Basic microfluidics and live-cell imaging device; scratch growth chambers and liquid flow channels into microscope slide; attach 2–3 pumps; and control *via* arduino/screen

Materials:

- Ilka's lab microscope: **available**
- Microscopy slides: **available**
- 2–3 peristaltic pumps for microfluidics: **obtain**
- Sainsmart's Arduino Mega + Touchscreen: **obtain**

2 Program

2.1 Day 1 <12:00 : Building Bioreactors

Talks, 30-60 min:

- Rob's DIY Reactor - The Beginnings: The Captor - Arduino-controlled mini PBR
- Dougie's DIY Reactor - 20 yrs Later
- Avantes - Spectrometry: Spectrometry applications, incl. NIR for metabolite measurements and OD; software interface to Avantes spectrometers
- CellDeg - Optimizing Photosynthetic Growth: Introduction to CellDeg's 2.5 k Euro algal growth setup (overnight 30 g/L cyano biomass)

2.2 Day 1 >13:00 : Hack'a'thing I

- Introduction to the Gas'o'meter: connecting sensors with Arduino, making an autonomous measurement device via Sainsmart's Touch Screen
- Introduction to Rob's reactor: complete setup for photosynthetic growth
- Self-organizing into teams: lab hardware (tubing etc.), control hardware (soldering etc.), software and/or by projects (1.1–1.7)

2.3 Day 2 : Hack'a'thing II

- Hardware I: soldering, tubing
- Software I: probe/sensor/pump \Leftrightarrow arduino/raspi interfaces
- Visit HHU's fine mechanics and glas blower work-shops, place orders for stuff missing for above goals

2.4 Day 3 : Hack'a'thing III

- Hardware II: Integrate projects 1.1,1.2&1.3 into a simple DIY reactor and/or with PSI FMT150 or Multicultivator
- Software II: arduino/raspi \Leftrightarrow master/server interface
Standard data formats and interfaces
- Brain storming: relation of data and models and beer

3 Outlook: 2nd QTB PBR Hack'a'thing

3.1 Growth Dynamics: Photobioreactors in Research

Talks, 30-60 min:

Nir Keren, Hellingwerf, Jan Cervený, Dougie Murray, something microfluidics?

3.2 Single Cell Dynamics: Microfluidic Devices

Integrate project 1.7 with the simple microscope in Ilka's lab, or a more advanced system (CAi?)

3.3 Omics: Sterile and Automated Sampling Devices

Proper sampling for high-throughput data (mass spectrometry, sequencing) acquisition