Bill of Materials

1 Introduction

OpenScope is a low-cost open-source microscope developed by the 2015 Cambridge-JIC iGEM team and based on Dr Richard Bowman's inverted bright-field microscope, the PiScope [1].

OpenScope is a modular microscope: the most basic version of the microscope is controlled manually, but motors can be added for finer control. It is also possible to make the microscope fully battery-powered. In terms of imaging modes, OpenScope can be used for bright-field imaging only, or extended to include fluorescence and dark-field imaging.

The aim of this document is to list the materials needed in order to build an OpenScope, and provide a cost estimate depending on which imaging and motorisation options are needed.

2 Manual bright-field microscope

The most basic version of OpenScope is controlled manually and is only capable of bright-field and dark-field imaging. All necessary components are listed in Tables 1 and 2 below.

TABLE 1: BASIC 3D PRINTED COMPONENTS	
#	**Part**
1	chassis
1	base
2	side supports for z axis
1	cube holder
1	z axis in 2 parts (vertical + horizontal)
1	3-legged camera holder
2	slide clips
1	bright-field cube (for RPi lens)
1	dark-field tube in 3 parts
3	manual gears
3	screw holders
3	motor-clip covers

Allow about 2 GBP worth of 3D printer filament to print all components. If a 3D printer is not available, the files can be sent to a 3D printing service - that would be slightly more expensive.

TABLE 2: BASIC OFF-THE-SHELF COMPONENTS			
#	**Part**	**GBP/unit**	**Details**
1	white LED (bright-field)	0.554	Mfr: Nichia; Part No. NSPW500DS (must be bought in multiples of 5)
2	25 mm long M4 screws	0.107	Buy at hardware store (reference price/unit for a pack of 10)
1	40 mm long M4 screw	0.107	Buy at hardware store (reference price/unit for a pack of 10)
3	M4 nuts	0.0043	Buy at hardware store (reference price/unit for a pack of 100)
3	M4 washers	0.0037	Buy at hardware store (reference price/unit for a pack of 100)
1	Raspberry Pi 2 Model B	26.60	Processor part number: BCM2836
1	Ralink RT5370 WiFi adapter	9.10	Amazon Standard Identification Number (ASIN): B00IQFGJSS
1	Arduino UNO with its USB B connector	21.00	Mfr: Arduino; Part No. A000066
1	breadboard	2.82	Mfr: Multicomp; Part No. MCBB400
1	16GB micro SD card	5.43	Model number: SDSDQUIN-016G-G4; ASIN: B00MBTP8Q4
2	220 ohm resistors	0.065	Brand: TE Connectivity; Part No. CFR100J220R (must be bought in multiples of 10)
1	ethernet cable	9.99	Mfr: Sandstrm; Product code: 874926
1	100 m spool insulated single-core wire	13.45	Brand: Lapp; Part No. 4510021
1	RPi camera	22.18	Brand: Raspberry Pi; Part No. PiNoir
1	RPi ribbon cable	0.00	Comes with RPi camera
1	2A micro USB power cable	5.66	Mfr: RS; Part No. HNP10I-microUSB
Total cost:		**117.259**	

The total cost of this manual bright-field/dark-field version is thus 120 GBP (3D printer filament cost included) but if hardware components are smartly sourced, this price can be brought down significantly.

3 Adding GFP fluorescence

In order to image GFP fluorescence, the following items must be added to the bill of materials:

TABLE 3: 3D PRINTED COMPONENTS FOR FLUORESCENCE	
#	**Part**
1	epicube (for RPi lens)
1	set of drawers (for filters and mirrors)

TABLE 4: OFF-THE-SHELF COMPONENTS FOR GFP FLUORESCENCE			
#	**Part**	**GBP/unit**	**Details**
1	blue LED (GFP)	0.225	Mfr: Kingbright; Part No. L-10934VBC/DS-D
1	550nm dichroic mirror, 25x16mm (GFP)	19.4	Mfr: Comar; Part No. 550 1Y 116
1	490nm excitation filter, 25x16mm (GFP)	19.4	Mfr: Comar; Part No. 495 1K 116
1	500nm emission filter, 25x16mm (GFP)	19.4	Mfr: Comar; Part No. 515 1B 116
Total cost:		**58.425**	

Thus the cost of adding GRP fluorescence to the microscope is 59 GBP at most. Note that the filters listed are larger than needed. If cut carefully into 10x6 mm rectangles, each emission or excitation filter can be used for 6 microscopes, and the dichroic mirror, cut into 10x10 mm squares, can be used for two microscopes. This brings down the cost of adding GFP fluorescence to around 17 GBP per microscope.

4 Motorising the stage

For a motorised microscope, the following components must be added to the bill of materials:

TABLE 5: 3D PRINTED COMPONENTS FOR MOTORS	
#	**Part**
3	screw holders
3	motor-clip holders
1	battery holder for RPi

TABLE 6: OFF-THE-SHELF COMPONENTS FOR MOTORS			
#	**Part**	**GBP/unit**	**Details**
3	stepper motors	3.95	Mfr: Adafruit Industries; Part No. 858
2	UNL2003A Darlington driver chips	0.42	Mfr: Texas Instruments; Part No. ULN2003AN
1	9V battery connector	0.172	Brand: RS; Stock No. 489-021
Total cost:		**12.862**	

Therefore, the cost of motorising the microscope is around 13 GBP.

5 Other additions

Other possible expansions include:

- For better resolution, though with a smaller field of view, add a ball lens and supporting printed parts:
  - 1 bright-field cube (for ball lens): 3D printed
  - 1 epicube (for ball lens): 3D printed
  - 1 ball lens: 12.20 GBP, Mfr: Comar; Part No: 03 VQ 04
- To make the microscope fully battery powered, add:
  - 1 extra battery holder for RPi: 3D printed
  - 1 extra 9V battery connector: 0.172 GBP; Brand: RS; Stock No. 489-021
  - 1 Low Profile MoPi power board: 25.00 GBP; Product code: MOPI-LP
- To avoid sharing the RPi camera between different imaging cubes add:
  - 1 extra RPi camera: 22.18 GBP; Brand: Raspberry Pi; Part No. PiNoir

6 Conclusion

The simplest cheapest version costs at most 120 GBP. Adding GFP fluorescence costs between 17 and 59 GBP. Adding motors costs 13 GBP. Scaling up the production of these microscopes would significantly reduce their total cost, as components could be sourced in bulk.

7 References

[1] James P. Sharkey, Darryl C. W. Foo, Alexandre Kabla, Jeremy J. Baumberg and Richard W. Bowman, *A one-piece 3D printed microscope and flexure translation stage*, online at: **arXiv:1509.05394 [physics.ins-det]**. (Accessed 18 Sep. 2015).