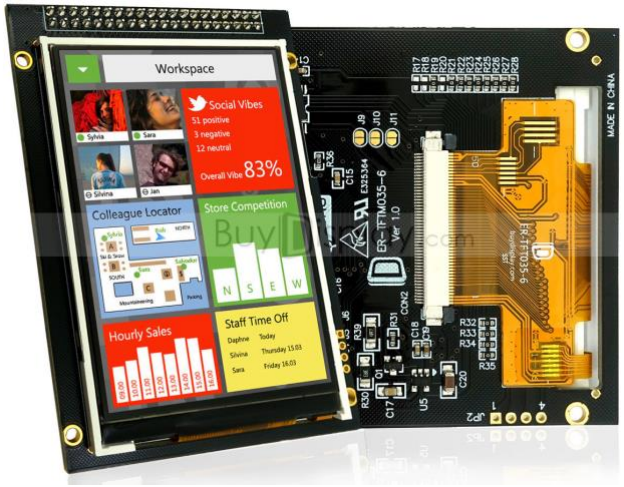
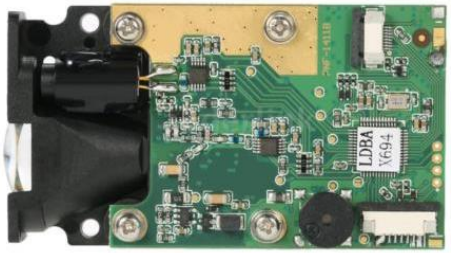
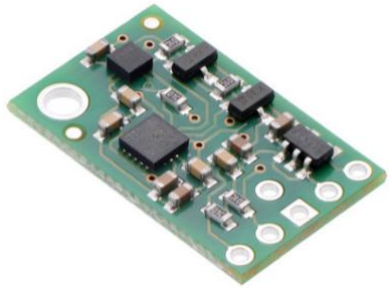
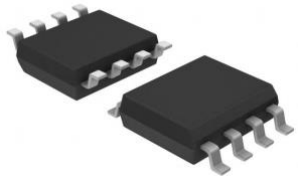
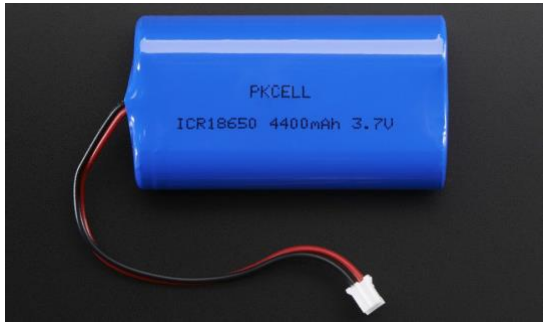
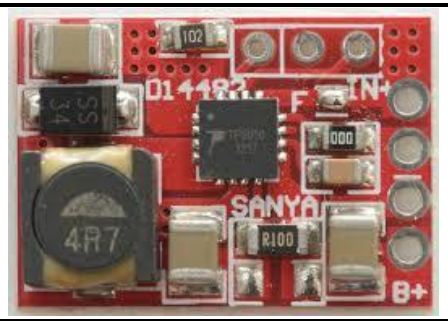
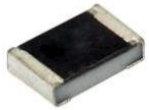
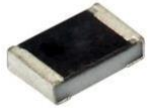
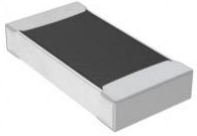
Caveatron Bill of Materials
Hardware Revision: C
Date: 2022-11-13

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Main Processor	1	PJRC Electronics	Teensy 4.1	Teensy 4.1	PJRC Store	
Notes: *The main system processor*. Available from multiple vendors. Versions with and without the pins pre-installed are available (link above is with pins). Either of the versions (with or without Ethernet) are fine.						
Touchscreen LCD	1	BuyDisplay	N/A	LCD 3.5” 320x480 TFT Display Module, OPTL Touch Screen w/Breakout Board Options: -Capacitive touch panel -16-bit 8080 40-pin header -3.3V supply -No font chip	BuyDisplay	
Notes: *The display and user interface. Note that this is the capacitive touchscreen version unlike the resistive version used previously.*						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Laser Rangefinder **OPTION 1**	1	JRT Meter Tech., Co, Ltd.	Unknown	40m – 60m Laser Distance Sensor Module	Ebay Availability changes frequently. Site linked above has availability as of the date of this BOM	
Notes: *Used for station distance measurements*. There are several variants of this module including those that use ASCII or HEX-based commands both of which are supported by the Caveatron. Based on the datasheets I have reviewed I think any variant of this style should work. This style is the preferred LRF module and the only one for which the Rev C enclosure is designed to accommodate.						
Laser Rangefinder **OPTION 2**	1	JRT Meter Tech., Co, Ltd.	Unknown	100m Laser Distance Sensor Module	Ebay Availability changes frequently. Site linked above has availability as of the date of this BOM	
Notes: *Used for station distance measurements*. This rangefinder module uses the same ASCII protocol and power supply as option 1 above but has a longer range so can be substituted. However the current enclosure design does not have space for it so a customized enclosure would be required.						
Laser Rangefinder **OPTION 3**	1	Uni-T	UT390B	Laser Distance Meter	Availability very limited. Internet searches will still occasionally find one.	
Notes: *Used for station distance measurements*. This item is long since discontinued and is almost impossible to find anymore. Do not confuse this with the UT390B+, which is more widely available but does not have an accessible serial port, so is not useable. The UT390B+ has a bubble level in the upper left which the UT390B does not. The UT390B must be disassembled and the LCD removed to access the electronics board. The electronics and code in Rev C still support this LRF although the enclosure does not.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Compass Module **OPTIONAL BUT HIGHLY RECOMMENED**	1	Witmotion	RM3100	WitMotion High-Precision RM3100 Military-grade Magnetometer Sensor	Amazon or Witmotion	
Notes: *Used to determine the azimuth angle of the Caveatron*. This is the best currently available low-cost magnetometer module option. This magnetometer has proven more accurate, reliable and with less drift than another other tested. It is optional since the Pololu IMU module below also includes a magnetometer but the Pololu magnetometer is much more noisy and less accurate, so it is highly recommended that you use this module.						
IMU Module	1	Pololu	MinIMU-9 v5 (#2738) Or AltIMU-10 v5 (#2739)	MinIMU-9 v5 Gyro, Accelerometer, Compass (LSM6DS33, and LIS3MDL Carrier)	Pololu	
Notes: *Used to determine orientation of the Caveatron and measure inclination*. The AltIMU-10 v5 is an equivalent part and can also be used (the altitude sensor is not used). The MinIMU-9 and AltIMU-10 v3 and v4 are still supported by the code and electronics but are no longer available.						
Font/Graphics IC	1	Winbond	W25Q128JVSIM	W25Q128 SPI flash memory IC, 128 Mbit, quad 8-SOIC	Digikey and many other source	
Notes: *Contains the fonts and graphics used for the GUI.* You must use the 128Mbit 8-SOIC package version – other sizes may not work. It is soldered to the pad location on the underside of the Teensy 4.1 that is directly under the micro-SD slot and closest to the edge.						

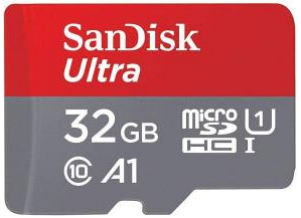
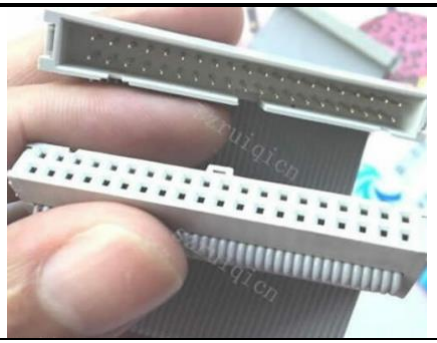
Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Pack **OPTION 1**	1	Dantona Industries	L37A52-2-1-2WX	Li-Ion Battery Pack, 3.7V, 5200 mAh, 18650, wire leads with connector	Digikey	
Notes: *Primary system battery*. This one is the best choice since it is lower cost and already has a connector.						
Battery Pack **OPTION 2**	1	Tenergy	31001	Tenergy Li-Ion 18650 3.7V 5200mAh Rechargeable Battery PCB module with Bare Leads	Tenergy	
Notes: *Primary system battery*. Identical size and capacity to Option 1, but more expensive and you must add a connector.						
Battery Pack **OPTION 3**	1	Adafruit	354	Lithium Ion Battery Pack - 3.7V 4400mAh	Adafruit	
Notes: *Primary system battery*. Lower capacity than options 1 or 2. Has a connector.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Charger Module	1	Unknown	TP5000	Lithium Ion 3.7V Charger Module	Amazon	
Notes: *Battery charging module.* There are several sources for this module and at least 2 variants. Be sure to get the variant with the 4 power pins all on the same side. A solder bridge is required to make it functional and a 0.2 ohm resistor can be added to increase the charge current above 1 Amp. These are usually on a red PCB but can also be green from other sources.						
10k resistor	2	Various	Various	SMD resistor, 10k-ohm, 1%, 1206 package	Digikey	
Notes: *Resistor for battery monitor voltage divider and for IMU power input.* Available from numerous manufacturers and vendors - the above is only 1 example. ¼ watt or less is fine since this carries no significant current.						
3.3k resistor	1	Various	Various	SMD resistor, 3.3k-ohm, 1%, 1206 package	Digikey	
Notes: *Resistor for battery monitor voltage divider.* Available from numerous manufacturers and vendors - the above is only 1 example. ¼ watt or less is fine since this carries no significant current.						
0.2-ohm resistor **OPTIONAL**	1	Various	Various	SMD resistor, 0.2-ohm, 1%, 0.5W, 1206 package	Digikey	
Notes: *Resistor for battery charger module.* Only needed if you want to increase the charge current of the TP5000 from the default 1 Amp to 1.5 Amp.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Voltage Regulator – 5V	1	Pololu	2119	5V Step-Up/Step-Down Voltage Regulator S7V7F5	Pololu	
Notes: *Power supply for Teensy.*						
LRF Voltage Regulator	1	Pololu	2118	Pololu Adjustable Step-Up/Step-Down Voltage Regulator S7V8A	Pololu	
Notes: *Power supply for Laser Rangefinder*. Output needs to be set to 3.0V.						
LIDAR Voltage Regulator **OPTION FOR RPLIDAR A1M8**	1	Pololu	2123	Pololu 5V Step-Up/Step-Down Voltage Regulator S7V8F5	Pololu	
Notes: *Power supply for RPLIDAR A1M8.* If using the RPLIDAR S2, this cannot source enough current.						
LIDAR Voltage Regulator **OPTION FOR RPLIDAR S2**	1	Pololu	2891	Pololu 5V Step-Up Voltage Regulator U3V70F5	Pololu	
Notes: *Power supply for RPLIDAR S2.* Higher current alternative to the regulator above - needed for the S2. Can also be used with the A1M8.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Power Switch Module	1	Pololu	2808	Mini Pushbutton Power Switch with Reverse Voltage Protection, LV	Pololu	
Notes: *Turns on and off system power when pushbutton power switch is pressed and also controls timed auto power-off.*						
RTC Battery Holder	1	MPD and others	BC501SM	Coin Cell Battery Holder - 12mm (for CR1220 batteries)	Digikey Amazon	
Notes: *Holds a CR1220 battery to provide power to maintain the Real-time clock on the Teensy.* Identical holders are available from many sources with differing part numbers but those I have checked that are surface mount all have nearly identical dimensions so should work.						
Piezoelectric Buzzer	1	Uxcell	A14062400ux0199	uxcell A14062400ux0199 5 Pcs DC 2-28V 80Db Sound Electronic Passive Buzzer Alarm Black, 22 x 4.5 mm	Amazon	
Notes: *Indicator buzzer.*						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Power Switch & Charging LED	1	Adafruit	3350	Rugged Metal Pushbutton - 16mm 6V RGB Momentary	Adafruit Amazon	
Notes: *On/Off power switch and charge indicating ring LED.* This one enables separate colors on the ring LED for indicating charging and charge complete. These can be found at other sources as well but if you buy from another source be sure to get the common anode version.						
USB Jack	1	GT Contact	GT114200-10 (RR-114200-10)	Mini USB-B C2 size Plastic Panel Mount	USBFirewire.com	
Notes: *USB jack for data download, battery charging, and loading of software and calibration parameters*. This is the version with the solder pins on the inside. If you prefer a USB-micro connector, that is available as part number RR-11A200-10 and is an identical fit.						
Item	**Qty**	**Manufacturer**	**Mfr. P/N**	**Description**	**Suggested Vendor Link**	**Photo**
USB Cap	1	GT Contact	GT1C522122 (RR-1C522122)	Seal Cap	USBFirewire.com	
Notes: *Waterproof cap for USB jack.* This cap works for either the mini or micro USB options.						

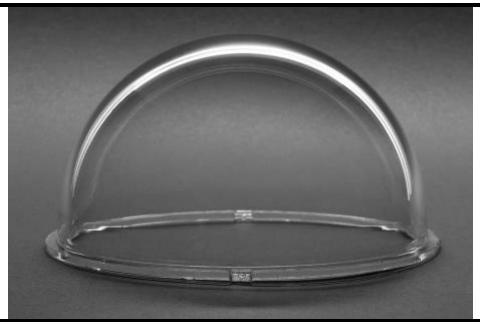
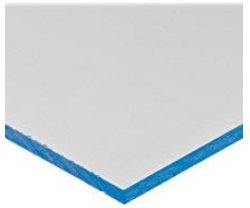
Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
MicroSD Card	1	Various	Various	SanDisk 32GB Ultra microSDHC UHS-I Memory Card	Amazon and many other sources	
Notes: *Storage for Caveatron data.* Numerous brands and sources available. MicroSD card must be SDHC type not larger than 32 GB (smaller capacities are fine as well). SanDisk brand is preferred as they are generally the most reliable.						
Teensy USB connector	1	N/A	N/A	Micro USB Male Solder Connector	Amazon and many other sources	
Notes: *For the cable to connect the exterior USB jack to the Teensy*. Wires are soldered between this part and the USB jack connector pins. Note that only the D+, D-, and GND are connected on this plug. The USB power (and a second GND wire) goes from the USB jack to a plug on the main PCB.						
LCD Connector Cable	1	N/A	N/A	40 pin IDE Male to Female Extension Cable, 4" (10 cm) or 6" (15 cm)	Ebay or Amazon	
Notes: *Cable to connect to LCD Touchscreen from the Caveatron main board.* Cables longer than 6" would take up too much space in the enclosure while those shorter than 4" are not long enough. These are available from multiple vendors. Note that some of these connectors do not include one of the middle pins, however those are fine since that pin is not used.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
JST Connector 5-pin	2 or 3	Various	JST-XH	JST 2.54mm pitch, 5 pin, male connector	Amazon, Ebay and others	
Notes: *Connector for LRF, power switch, and LIDAR.* If you order them prewired as in the photo, be sure they are at least 100 mm in length.						
JST Connector 2-pin	3 or 4	Various	JST-XH	JST 2.54mm pitch, 2 pin, male connector	Amazon, Ebay and others	
Notes: *Connector used for USB data, USB power, piezo buzzer, and battery.* If you order them prewired as in the photo, be sure they are at least 100 mm in length. (You won't need one for the battery if you order a battery that is pre-connectorized.						
Socket Headers 1	1 (6 pin positions needed)	Prec-Dip or others	310-87-106-41-001101	Socket header, 0.1" pitch, 4.2 mm insulation height, single row, 6 pins	Digikey and others	
Notes: *Header sockets for RM3100 magnetometer*. Only needed if you are using the RM3100. Short header needed since the RM3100 has tall components. This header size is matched to the RM3100 brackets. Other variants with different numbers of pins are available. 4 pins are needed on one side and 2 pins on the other.						
Socket Headers 2	3 (54 pin positions needed)	Prec-Dip or others	801-87-024-10-001101	Socket header, 0.1" pitch, 7.0 mm insulation height, single row, 24 pins	Digikey and others	
Notes: *Header sockets for Teensy and IMU.* Optional but this shorter size is preferred over the more common 8.51mm height to avoid interference with the display. Other variants with different numbers of pins are available. Two sets of 24 pins and 1 additional pin are needed for the Teensy and 5 pins are needed for the IMU module.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Screen Protector	1	Supershieldz	N/A	iPhone SE and iPhone 5 Screen Protector	Amazon	
Notes: *Protection film for touchscreen.* Needs to be cut to length. Most any PET screen protector film for iPhone 4, 4S, 5, 5s, or SE should work as they have the same screen width as the 3.5" LCD. Multiple vendors produce a similar product.						
Laser Rangefinder Optical Filter	1	Rosco	299	Roscolux 1.2 Neutral Density Filter, 20x24"	Adorama	
Notes: *Optical filters for the LRF receiver to only accept readings from the retroreflective card.* This filter only has half the optical density required, so must be folded in half when installed. Other neutral density films are fine so long as they are sufficiently dark to prevent the LRF from getting a signal from a non-retroreflective surface but no so dark that they reduce the range from the retroreflective surface.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LIDAR **OPTION 1**	1	Slamtec	RPLIDAR A1M8	LIDAR 360 Degree Laser Range Scanner, 12 m range	RobotShop	
Notes: *Scanning LIDAR sensor*. Other models that should also work but have not been tested include RPLIDAR A2M6, A2M7, A2M8, and A3. These LIDARs are triangulation-based. Available from several sources.						
LIDAR **OPTION 2**	1	Slamtec	RPLIDAR S2	LIDAR 360 Degree Laser Range Scanner, 30 m range	RobotShop	
Notes: *Scanning LIDAR sensor*. The S2 has 2.5x the range, can collect 4x the number of points per second, has a faster rotation rate, and is smaller, but is more expensive. This LIDAR is a time-of-flight LIDAR. Available from several sources.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Threaded Inserts for Enclosure	10	Initeq		#6-32 Threaded Heat Set Inserts for 3D Printing (Long)	Ebay	
Notes: *Heat set threaded inserts used in 3D printed enclosure.*						
Threaded Inserts for external mounting (Optional)	1	Initeq		#1/4-20 1/4" Threaded Heat Set Inserts for 3D Printing (Short)	Ebay	
Notes: *Heat set threaded inserts used in 3D printed enclosure for external mounting.* This is an optional part if you plan to attach something external to the Caveatron (like a handle) or mount it to a tripod.						
Threaded Inserts for RPLIDAR A1M8 Standoffs **For RPLIDAR A1M8 only**	4	Initeq	INM2504	M2.5-0.4 M2.5 Threaded Heat Set Inserts for 3D Printing (Long)	Ebay	
Notes: *Heat set threaded inserts used in 3D printed LIDAR enclosure for RPLIDAR A1M8 standoffs.* The standoffs that screw into these are included with the RPLIDAR.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LIDAR Window **For RPLIDAR S2 only**	1	JMX	N/A	3.1” Acrylic Dome	Amazon	
Notes: *Window for the RPLIDAR S2.* This will only work for a TOF type LIDAR. Curved windows do not work with triangulation LIDARs like the A1 series.						
LIDAR Window **For RPLIDAR A1M8 only**	1	Small Parts	5302441212	Acrylic Sheet, Transparent Clear, Standard Tolerance, ASTM D788, 0.118" Thickness, 12" Width, 12" Length	Amazon	
Notes: *Transparent acrylic sheet for LIDAR window.* This 0.118” transparent acrylic sheet is used for the RPLIDAR A-series windows. Requires cutting to size. Acrylic seems to be the most transparent with the least distortion and defects of the various clear plastics tested, which is important for getting good LIDAR and rangefinder readings. A flat window is required for the A-series triangulation-based LIDAR modules.						
LRF Window Material	1	Sibe Polymers	5064981212	Clear Acrylic Plexiglass 12" x 12" - 3/32" (.090)	Amazon	
Notes: *Transparent acrylic sheet for LRF window on Main Body.*						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Strap Attachment Hardware	1	122317	Hillman Group	D-Ring Hangers	Lowes Amazon	
Notes: *Small D-rings for attaching neck strap.* Available from multiple sources and similar parts likely available from other vendors.						
Neck Strap	1	DOROM	N/A	DOROM Universal Adjustable Slim Shoulder Sling Neck Strap for All Camera DSLR SLR	Amazon	
Notes: *Neck Strap.* This neck strap works well, but other options are available. Recommend a nylon camera strap of 52-60” in length and about 3/8” wide in the ends.						
O-Ring Seals	4 ft	The O-Ring Store	N50.103/10	0.103" (2.62mm) Buna-N 50 O-Ring Cord Stock, 10' Piece, Black	O-Ring Store	
Notes: *O-Ring material for seals in main enclosure and LIDAR module.* This 50 durometer material is preferred over more readily available 70 durometer since it is softer and can make a tighter seal. Must cut to length and glue ends (this vendor also sells O-ring glue in small quantities.) Other vendors sell similar material.						

Other Required Items:
Caveatron Rec C Printed Circuit Board
CR1220 Battery
Single row male headers, 2.54 mm (0.1”) pitch
Double row female headers 2x20 (for 40 pin LCD Connector), 2.54 mm (0.1”) pitch
Soldering supplies
6-32 x 1” flat head machine screws (4x)
6-32 x 3/8” flat head machine screws (4x)
6-32 x 3/8” pan head machine screws (4x)
6-32 x 5/8” pan head machine screw (1x)
4-20 x ¼” thread rolling screws (10x)
M4x0.7 x 6mm (or 5mm) pan head machine screws (4x)
4-20 x ½” thread rolling screws (6x)
2-28 x ¼” thread rolling screws (11x)
PETG filament for 3D printed parts
O-Ring grease
O-Ring epoxy
Size 114 O-ring (for the LIDAR-Main body interface or make your own from the O-Ring cord above)
Flexible waterproof epoxy sealant
Adhesive-backed foam
Tape (Kapton or cellophane)

Notes: *For assembly and electrical interconnections between boards.*