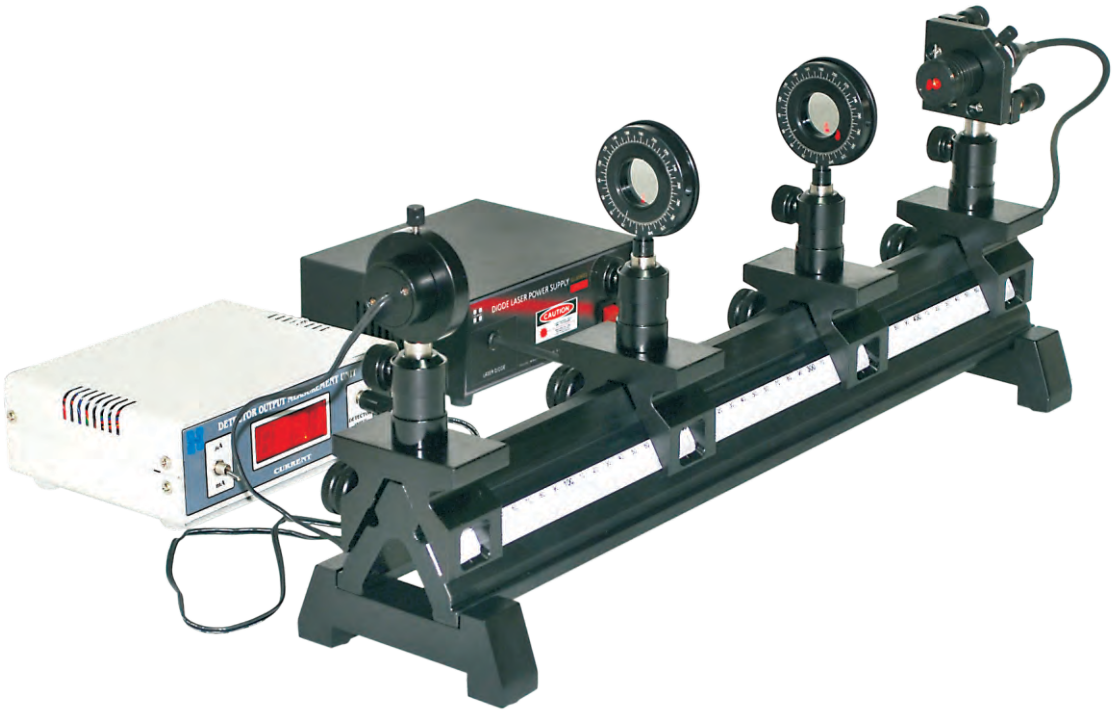
HOLMARC

Instruction Manual



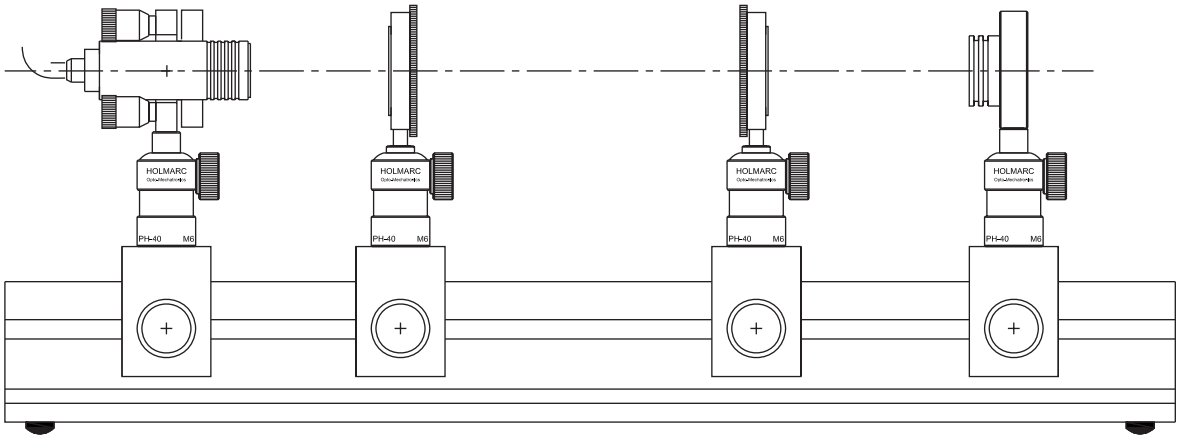
Malus Law Apparatus

Model : HO-ED-P-02

CONTENT Page

Product Features

HOLMARC's Malus' law apparatus Model **HO-ED-P-02** helps to understand polarization properties of light. In this experiment we will attempt to demonstrate Malus' Law by passing light through a pair of polarizers and recording the level of light which is transmitted based on the angle between them. Laser light is used as the source in the experiment since the light gets completely (almost) extinguished by crossed polarizers.



Historical introduction on polarization

Historically, the name "polarization" is due to Etienne-Louis Malus (1809). Polarization is an intrinsic property of light connected with the transversality character of the "optical vibration".

Malus shows how (linearly) polarized light can be artificially produced by means of reflections and refractions on the surfaces of(what we now call) dielectric bodies such as glass, water, etc.

Getting Started

a. Let's Start

Please check whether the following items are there in the package delivered.

1. Diode Laser with power supply (3mW 650nm Red)
2. Kinematic Laser mount
3. Polarizer
4. Analyzer
5. Detector Mount
6. Pinhole Photo Detector with output measurement unit
7. Optical Rail (500 mm)
8. Malus Law Apparatus instruction manual

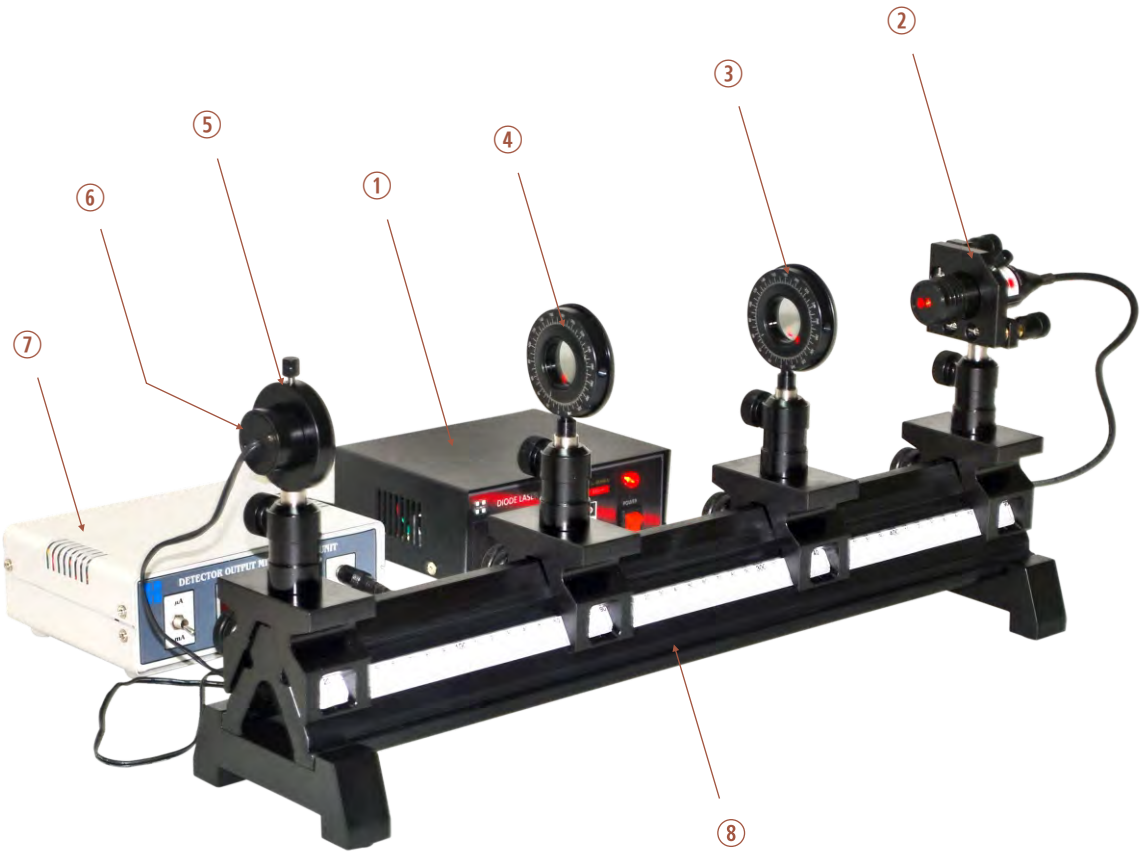
b. Safety Instructions

- Please try to work in a low light and dust free atmosphere.
- Take care while using polarizer, please don't touch on the polarizing sheets as it may damage the sheets.

Caution : Do not allow laser beam to fall directly into the eyes. It may damage the eyes or cause severe viewing problems.

- Provide stabilized power to protect all the electronic devices used in the experiment.

c. Parts Listing



1. Diode Laser with power supply (3mW 650nm Red)
2. Kinematic Laser mount
3. Polarizer
4. Analyzer
5. Detector Mount
6. Pinhole Photo Detector
7. Detector Output Measurement Unit
8. Optical Rail (500mm)

d. Components

1. Optical Rail

Specifications:

Length ..... 500 mm

Material .... Black anodized aluminium alloy

2. Polarizer

Specifications:

Type ..... Sheet polarizer

Accuracy ..... 2^0 / division

Manual 360^0 rotation

3. Diode Laser with Power Supply

Specifications:

Power Input ..... 230V AC / 50 Hz

Colour ..... Red

Output Power ..... 3 mW

Wavelength ..... 650 nm

4. Kinematic Laser mount

Specifications:

Degrees of freedom ..... +/- 4 degrees

Fine adjustments using 80 tpi lead screws

Material .... Black anodized aluminium alloy

5. Analizer

Specifications:

Type ..... Sheet polarizer

Accuracy ..... 2^0 / division

Manual 360^0 rotation

6. Detector Mount

Specifications:

Diameter 30mm

Material .... Black anodized aluminium alloy

7. Pinhole Photo Detector

Specifications:

Detector type ..... Photo transistor

Pin hole diameter ..... 0.7 mm

8. Detector Output Measurement Unit

Specifications:

Detector supply ..... 5 V

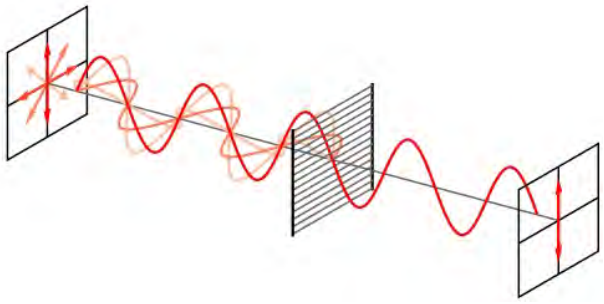
Power input ..... 230 V - 50 Hz

Measurement range ..... 0 - 199 µA / mA

Display ..... 3 digit 7 segment led display

Theory

Light waves are transverse in nature; i.e., the electric field associated with the light wave is always at right angles to the direction of propagation of the wave. This can be easily demonstrated using a simple polarizer. A polarizer consists of long chain molecules aligned in a particular direction. The electric vector associated with the propagating light wave along the direction of the aligned molecules get absorbed. Thus, if an unpolarized light wave is incident on such a polarizer then the light wave will get linearly polarized with the electric vector oscillating along a direction perpendicular to the aligned molecules; this direction is known as the optic-axis of a polarizer.



Thus, if the light from a source (like a sodium lamp) passes through a polarizer sheet P1, it is observed that its intensity is reduced by half. Rotating P1 has no effect on the transmitted beam and transmitted intensity remains constant. Now, let another polarizer P2 be placed after P1. As expected, the light from the lamp is reduced in intensity on passing through P1 alone. But now rotating P2 has a dramatic effect on the light coming from P2. In one position, the intensity transmitted by P1 followed by P2 is nearly zero. When turned by 90º from this position, P2 transmits nearly the full intensity emerging from P1.

Etienne - Louis Malus,

Born : Jun. 23, 1775, Paris
Died : Feb. 23, 1812, Paris

The above experiment can be easily understood by assuming that light passing through the polarizer P1 gets polarized along the optic axis of P1. If the optic axis of P1 makes an angle θ with the optic axis of P2, when the polarized beam pass through the polarizer P2 , the component E cos θ (along the optic axis of P1) will pass through P2 . Thus, as we rotate the polarizer P1 (or P2), the intensity will vary as : $I = I_o \cos^2\theta$ where I_o is the intensity of the polarized light after passing through P1 . This is known as Malus' law.

According to Malus', when completely plane polarized light is incident on the analyzer, (the second polarizer,P2), the intensity I of the light transmitted by the analyzer is directly proportional to the square of the cosine of angle between the transmission axes of the analyzer and the polarizer.

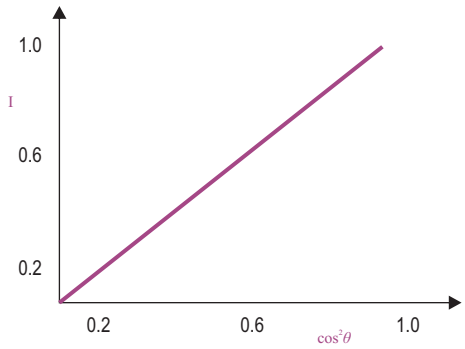


Fig. Photo detector current as a function of the $\cos^2\theta$

Do you know !

Polaroids can be used to control the intensity,insunglasses, windowpanes, etc Polaroids are also used in photographic cameras 3D movie cameras.

Experimental Procedure

1. First of all fix laser mount over the rail and insert laser module into the mount.

Fig (1)

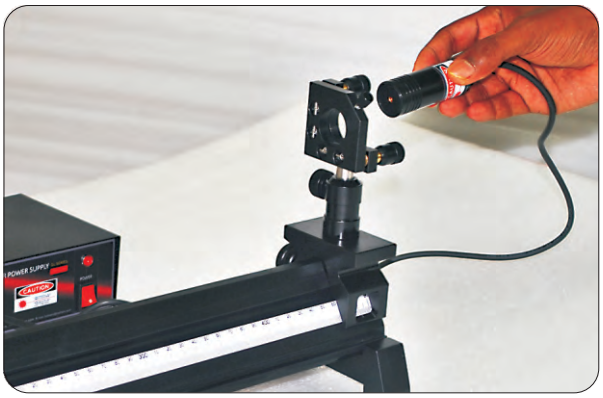


Fig (2)

2. Now introduce polarizer, also fix the detector mount at the other end of the optical rail.

Fig (3)

Fig (4)

3. Insert detector into the detector mount ,Now switch on the laser power supply and the detector output measurement unit use fine adjustments on the laser mount so that the light falls at the centre of the pinhole photo detector.(Also adjust the height of polariser so that light falls at the middle of the polarizer and reflects back to the laser aperture).

Fig (5)

Fig (6)

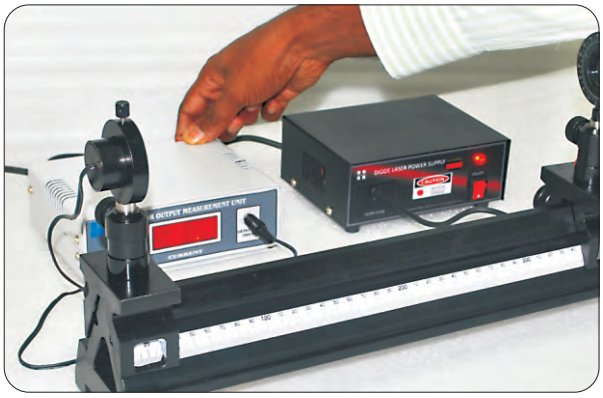


Fig (7)

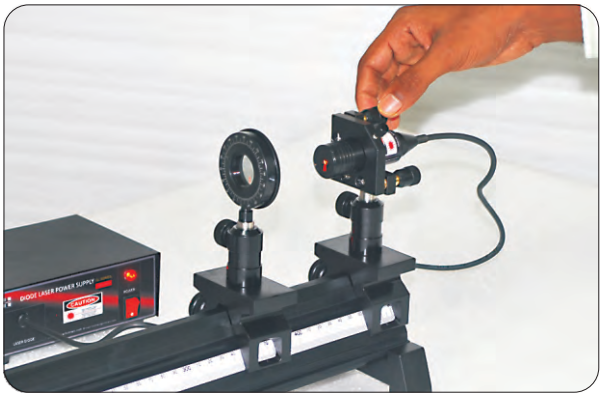


Fig (8)

4. Now rotate the polarizer so that the polarized beam gives maximum intensity and note it as I_0. And introduce the second polarizer called the analyzer in between the detector and polarizer.

Fig (9)

Fig (10)

5. Measure the maximum transmitted intensity using the detector , Note the transmission axis of analyzer with respect to the polarizer. Start rotating the analyzer in increments of a fixed angle (say 5 degrees) and note the corresponding intensity output at the photo detector.

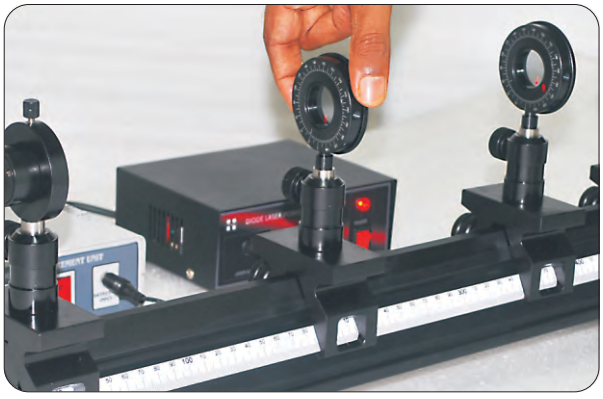


Fig (11)

Fig (12)

Draw a graph with rotated angle on the X - axis and corresponding output current on Y - axis, the graph between the orientations of the light intensity with respect to transmitted angle of the analyzer will follow the $\cos^2\theta$ function.

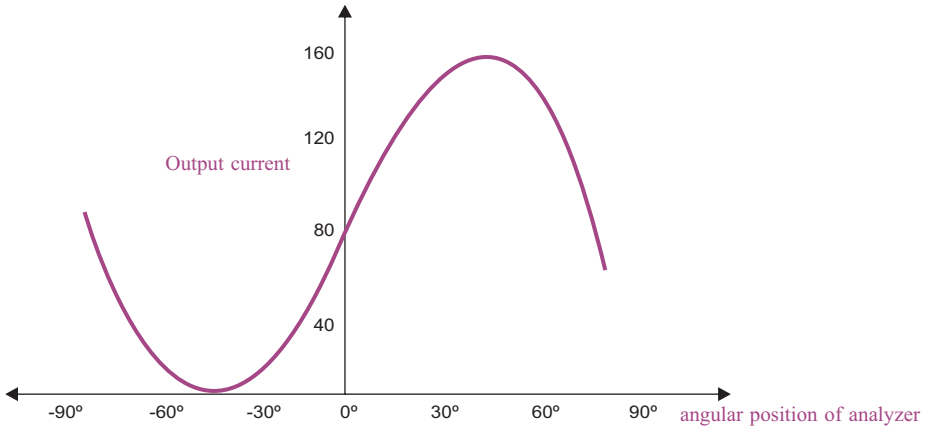


Fig. Photo detector current as a function of the angular position of the analyzer

Observations

Transmission angle of analyzer	Output current

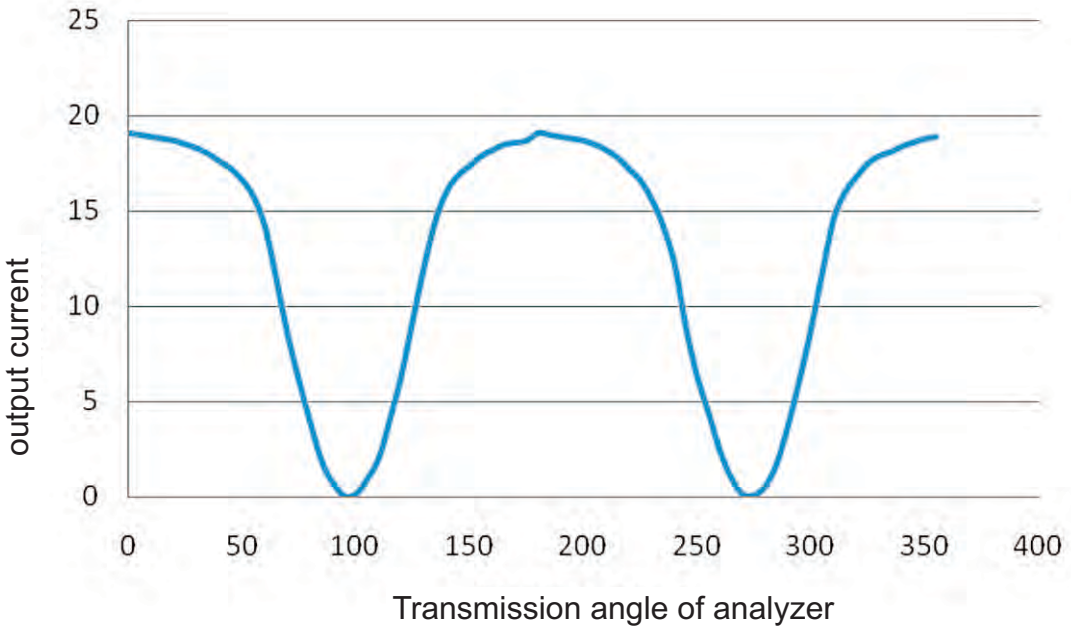
Result

Malus' law is thus verified

Experiment Example

Transmission angle of analyzer	Output current mA	Transmission angle of analyzer	Output current mA	Transmission angle of analyzer	Output current mA
0	19.3	120	5.6	250	4.2
5	19.1	125	8	255	2.8
10	18.8	130	9.1	260	1.5
15	18.5	135	11.2	265	0.6
20	18	140	13.1	270	0.05
25	17.7	145	14	275	0.8
30	17.4	150	15.1	280	1.9
35	17	155	15.8	285	3.4
40	16.7	160	16.5	290	5.3
45	16.2	165	17	295	8.9
50	15.5	170	17.8	300	10.5
55	14.1	175	18.1	305	11.8
60	13.3	180	18.5	310	13.1
65	11.5	185	19	315	14.8
70	9.8	190	18.8	320	16.1
75	5.5	195	18.6	325	16.8
80	1.7	200	18.1	330	17.4
85	0.8	205	17.8	335	17.9
90	0.1	210	17.2	340	18.2
95	0.6	215	16.5	345	18.6
100	1.2	230	15	350	19
105	1.9	235	14.1	355	19.1
110	2.4	240	13		
115	3.8	245	9.8		

Graph



To understand more about polarization it's fun to do Brewster's angle experiment HOLMARC also supply Brewster's angle measuring apparatus....

Maintenance Notes

- Always keep the equipment in a moisture and dust free atmosphere.
- Do not touch the active region of polarizer & Analyzer with bare hands
- 'Switch on' all the electronic devices used in this experiment at least once in a week.

Troubleshooting

If there is no out put from diode laser,

- check whether the power code is fixed properly with AC mains.

If there is no variation in intensity of the detector,

- Push the connector pin of pinhole photo detector to the power supply.
- Check if the intensity range selector is in correct position.

Technical Support

Before you call the HOLMARC Technical Support staff, kindly gather the following information:

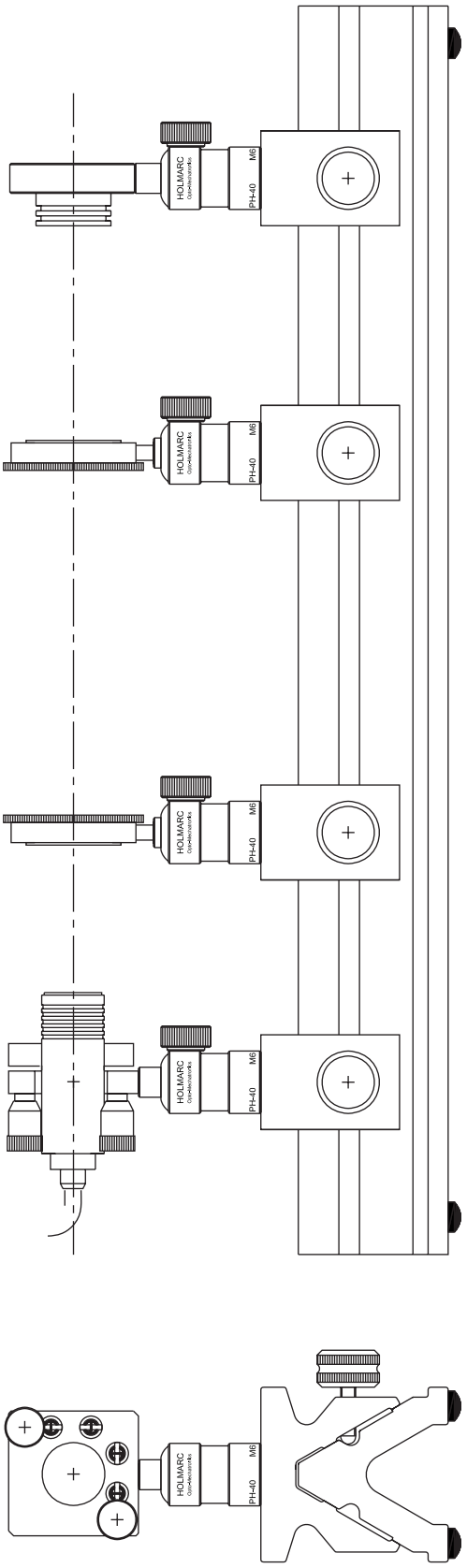
- Title and model number (usually listed on the label)
- Approximate age of apparatus
- Detailed description of the problem/sequence of events
- Have the manual in hand to discuss your query

Feedback

If you have any comments regarding our product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, kindly inform us. HOLMARC appreciates any customer feedback. Your inputs help us evaluate and improve our product.

For technical support, contact us at
Mob : 9388632098
E-mail: sales@holmarc.com
Web: www.holmarc.com

Mechanical Drawing



Holmarc Limited Warranty

Every Holmarc Instruments and its accessories are warranted by HOLMARC OPTO-MECHATRONICS LTD for a period of ONE YEAR from the date of original purchase.

Holmarc will repair or replace a product, or part thereof, found by Holmarc to be defective, provided the defective part is returned to Holmarc, with proof of purchase.

This warranty applies to the original purchaser and our distributors and is non-transferable.

Each returned part or product must include a written statement detailing the nature of the claimed defect, as well as the end user's name, address, and phone number.

This warranty is not valid in cases where the product has been abused or mishandled, where unauthorized repairs have been attempted or performed, or where depreciation of the product is due to normal wear-and-tear.

Holmarc specifically disclaims special, indirect, or consequential damages or lost profit which may result from a breach of this warranty. Any implied warranties which cannot be disclaimed are hereby limited to a term of one year from the date of original retail purchase.

Holmarc reserves the right to change product specifications or to discontinue products without notice.

Please refer our commercial invoice for warranty claim.

(Authorized Signatory)