User's Manual

PLANCK'S CONSTANT MEASURING SET-UP

Model: PC-101

(Rev : 01/04/2010)

Manufactured by :

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CERTIFIED COMPANY

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COPYRIGHT AND WARRANTY

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COPYRIGHT NOTICE

LIMITED WARRANTY

SES Instruments Pvt. Ltd warrants this product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. SES Instruments Pvt. Ltd will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. This warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of manufacturing defect or improper use by the customer shall be made solely by SES Instruments Pvt. Ltd. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packaging of the equipment for return shipment will not be covered by the warranty). Shipping costs for returning the equipment, after repair, will be paid by SES Instruments Pvt. Ltd.

EQUIPMENT RETURN

Should this product have to be returned to SES Instruments Pvt. Ltd, for whatever reason, notify SES Instruments Pvt. Ltd BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

Note : No equipment will be accepted for return without an authorization.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

1. The carton must be strong enough for the item shipped.
2. Make certain there is at least two inches of packing material between any point on the apparatus and the inside walls of the carton.
3. Make certain that the packing material can not displace in the box, or get compressed, thus letting the instrument come in contact with the edge of the box.

SAFETY INFORMATION

This Section addresses safety considerations and describes symbols that may appear on the Instrument or in the manual.

A **Warning** Statement identifies conditions or practices that could result in injury or death. A **Caution** statement identifies conditions or practices that could result in damage to the Instrument or equipment to which it is connected.

Warning

To avoid electric shock, personal injury, or death, carefully read the information in Table-1, "Safety Information," before attempting to install, use, or service the Instrument.

GENERAL SAFETY SUMMARY

This equipment is Class 1 equipment tested in accordance with the European Standard publication EN 61010-1.

This manual contains information and warnings that must be observed to keep the Instrument in a safe condition and ensure safe operation.

To use the Instrument correctly and safely, read and follow the precautions in Table 1 and follow all safety instructions or warnings given throughout this manual that relate to specific measurement functions. In addition, follow all generally accepted safety practices and procedures required when working with and around electricity.

SYMBOLS

Table 2 lists safety and electrical symbols that appear on the Instrument or in this manual.

Table 2. Safety and Electrical Symbols

Symbols	Description	Symbols	Description
	Risk of danger. Important information. See Manual.		Earth ground
	Hazardous voltage. Voltage >30Vdc or ac peak might be present.		Potentially hazardous voltage
	Static awareness. Static discharge can damage parts.		Do not dispose of this product as unsorted municipal waste. Contact SES or a qualified recycle for disposal.

Table 1. Safety Information

⚠⚠ Warning

To avoid possible electric shock, personal injury, or death, read the following before using the Instrument:

- **Use the Instrument only as specified in this manual, or the protection provided by the Instrument might be impaired.**
- **Do not use the Instrument in wet environments**
- **Inspect the Instrument in wet environments.**
- **Inspect the Instrument before using it. Do not use the Instrument if it appears damaged.**
- **Inspect the connecting lead before use. Do not use them if insulation is damaged or metal is exposed. Check the connecting leads for continuity. Replace damaged connecting leads before using the Instrument.**
- **Whenever it is likely that safety protection has been impaired, make the Instrument inoperative and secure it against any unintended operation.**
- **Have the Instrument serviced only by qualified service personnel.**
- **Always use the power cord and connector appropriate for the voltage and outlet of he country or location in which you are working.**
- **Never remove the cover or open the case of the Instrument before without first removing it from the main power source.**
- **Never operate the Instrument with the cover removed or the case open.**
- **Use only the replacement fuses specified by the manual.**
- **Do not operate the Instrument around explosive gas, vapor or dust.**
- **When servicing the Instrument, use only specified replacement parts.**
- **The equipment can remain Switched on continuously for five hours**
- **The equipment must remain Switched off for at lease fifteen minutes before being switched on again.**
- **The equipment is only for the intended use**
- **Use the equipment only as specified in this manual.**

Unpacking and Inspecting the Instrument

Every care is taken in the choice of packing material to ensure that your Instrument will reach you in perfect condition. If the Instrument has been subject to excessive handling in transit, there may be visible external damage to the shipping container and packing material for the carrier's inspection.

Carefully unpack the Instrument from its shipping container and inspect the contents for damaged or missing items. If the Instrument appears damaged or something is missing, contacts the carrier and SES immediately. Save the container and packing material in case you have to return the Instrument.

Storing and Shipping the Instrument

To prepare the Instrument for storage or shipping, if possible, use the original shipping container alongwith thermocoal corners, as it provides shock isolation for normal handling operations. If the original shipping container is not available, use any good cardboard box which is at least 2-3 inches bigger than the instrument on all sides, with cushioning material (thermocoal or styrofoam etc) that fills the space between the instrument and the side of this box.

To store the Instrument, place the box under cover in a location that complies with the storage environment specification described in the "Environment Sections" below.

Environment

Temperature

Operating ……. 0°C to 50°C
Storage …… 40°C to 70°C
Warm Up ……15 min to full uncertainty specification

Relatively Humidity (non-condensing)

Operating …….Uncontrolled (<10°C)
<90 % (10°C to 30°C)
<75 % (30°C to 40°C)
<45 % (40°C to 50°C)
Storage…….. -10°C to 60°C <95 %

Power Considerations

The Instrument operates on varying power distribution standards found throughout the world and must be set up to operate on the line voltage that will power it. The Instrument is packed ready for use with a line voltage determined at the time of ordering.

Replacing the Fuses

The Instrument uses one fuse to protect the line-power input and two fuses to protect current-measurement inputs.

Line-Power Fuse

The Instrument has a line-power fuse in series with the power supply. Table 3 indicates the proper fuse for each of the four line-voltage selections. The line-power fuse is accessed through the real panel.

1. Unplug the power cord.
2. Rotate the fuse holder cap to the right until the fuse POPS out.
3. Remove the fuse and replace it with a fuse of an appropriate rating for the selected line-power voltage. See Table 3.

Warning

To avoid electric shock or fire, do not use makeshift fuses or short-circuit the fuse holder.

Table 3. Line Voltage to Fuse Rating

Line Voltage Selection	Fuse Rating
220/ 240 V	0.5A, 250V (Slow Blow)
100/ 120 V	1A, 250V (Slow blow)

Connecting to Line Power

Warning

To avoid shock hazard, connect the factory supplies three conductor line power cord to a properly grounded power outlet. Do not use a two-conductor adapter or extension cord, as this will break the protective ground connection. If a two conductor power cord must be used, a protective grounding wire must be connected between the ground terminal and earth ground before connecting the power cord or operating the Instrument.

1. Verify that the Line voltage is set to the correct setting.

2. Verify that the correct fuse for the line voltage is installed.

3. Connect the power cord to a properly grounded three-prong outlet. See Figure 3 for line-power cord types available from SES. Refer to Table 4 for description of the line-power cords.

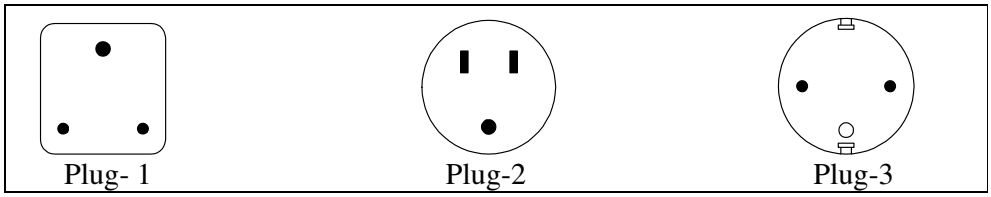


Figure 3. Line-Power Cord Types Available from SES

Table 4. Line-Power Cord Types Available from SES

Type	Voltage/Current	SES Model Number
India	240 V/ 5 A	Plug-1
North America	120 V/15 A	Plug-2
Universal Euro	220 V/16 A	Plug-3

Turning Power On

The On-Off switch on the front panel when points towards "ON" signs, indicates that the equipment has been switched on.

Cleaning the Instrument

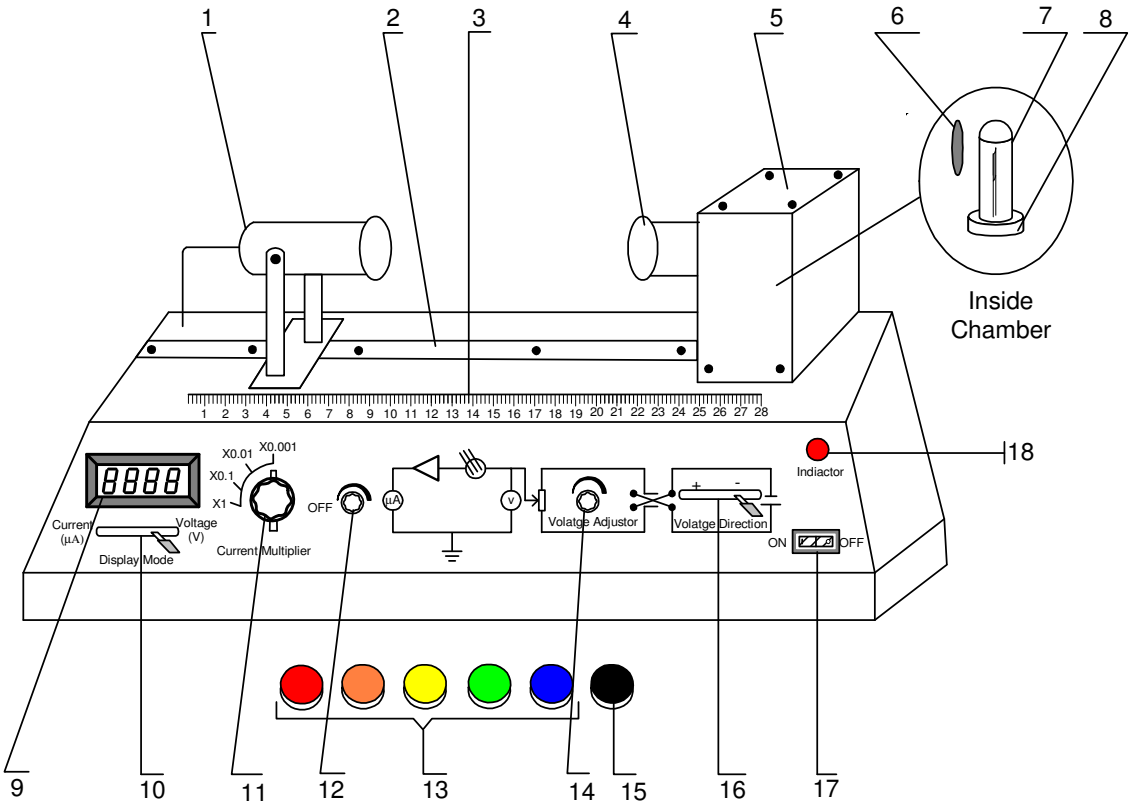
Warning

To avoid electric shock or damage to the Instrument, never get water inside the Instrument.

Caution

To avoid damaging the Instrument's housing, do not apply solvents to the Instrument.

If the Instrument requires cleaning, wipe it down with a cloth that is lightly dampened with water or a mild detergent. Do not use aromatic hydrocarbons, alcohol, chlorinated solvents, or methanol-based fluids when wiping down the Instrument.



1-Light source, 2-Guide, 3-Scale, 4-Drawtube, 5-Cover, 6-Focus lens, 7-Vacuum Phototube, 8-Base for holding the Phototube, 9-Digital Meter, 10-Display mode switch, 11-Current multiplier, 12-Light intensity switch, 13-Filter set, 14-Accelerate voltage adjustor, 15-Lens cover, 16-Voltage direction switch, 17-Power switch, 18-Power indicator.

Panel Diagram of Planck's Constant Experiment, PC-101

PACKING LIST

1. Planck's Constant measuring Set-up, PC-101: One
2. A Set of Filters:
   (i) Red: One
   (ii) Yellow I: One
   (iii) Yellow II: One
   (iv) Green: One
   (v) Blue: One
3. Lens Cover : One

MAJOR COMPONENTS OF SETUP

a. **Photo Sensitive Device**: Vacuum photo tube.
b. **Light Source**: Halogen tungsten lamp 12V/35W.
c. **Color Filters**: Red (635nm), Yellow – I (570nm), Yellow – II (540nm), Green (500nm) & Blue (460nm).
d. **Accelerating Voltage** : Regulated Voltage Power Supply

Output	: ± 15 V continuously variable through multi-turn pot
Display	: 3 ½ digit 7-segment LED
Accuracy	: ±0.2%

e. **Current Detecting Unit** : Digital Nanoammeter
It is high stability low current measuring instrument

Range	: X 1μA, 0.1μA, 0.01μA & 0.001μA with 100% over ranging facility
Resolution	: 1nA at 0.001μA range
Display	: 3½ digit 7-segment LED
Accuracy	: ± 0.2%

f. **Power Requirement**: 220V ± 10%, 50Hz.
g. **Optical Bench:** The light source can be moved along it to adjust the distance between light source and phototube scale length is 400 mm. A drawtube is provided to install color filter; a focus lens is fixed in the back end.

BRIEF DECRIPTION OF APPARATUS REQUIRED

1. **Light source :** 12V/35W halogen tungsten lamp.
2. **Guide :** Move the light source along it, the distance between light source and dark box chamber can be adjusted.
3. **Scale :** 400mm total length. The center of the vacuum phototube is used as zero point.
4. **Drawtube :** The forepart is used for installing color filter; a focus lens is fixed in the back end.
5. **Cover :** Used to cover chamber containing Phototube.
6. **Focus lens :** Make a clear image of light source on the cathode area of phototube.
7. Vacuum Phototube.

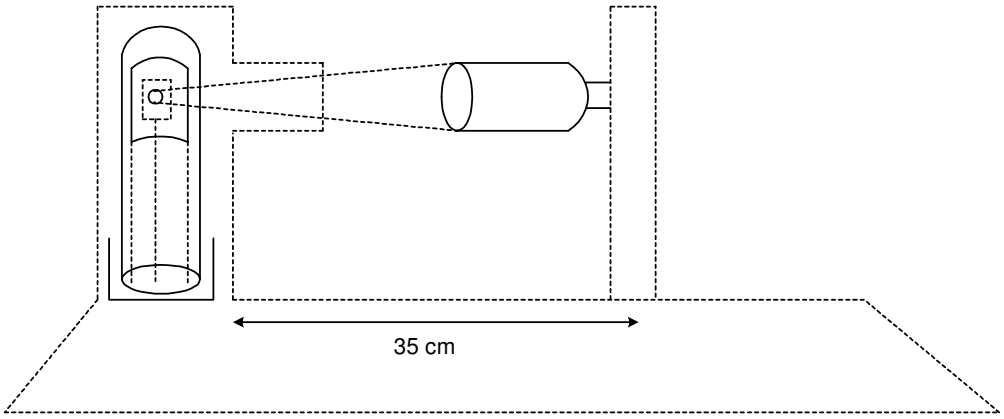


Fig. 1

8. Base for holding the Phototube
9. **Digital meter :** Show current (μA), or voltage (V).
10. **Display mode switch :** For switching the display between voltage and current mode.
11. Current Multiplier.
12. **Light intensity switch :** Switch for choosing light intensity. Up is for strong, middle is for off; down is for weak.
13. Filter set : Five pieces
14. **Accelerate voltage adjustor :** Knob for adjusting accelerating voltage.
15. **Lens Cover :** (For protecting the phototube from stray light during ideal period)
16. **Voltage direction, switch :** Switch for choosing voltage direction. ±15V accelerating voltage is provided.
17. Power switch.
18. Power indicator.

INSTALLATION AND ADJUSTMENT

1. Open the carton and takeout the apparatus. Put it on the table, open the top cover (5) and take out all the packing material around the phototube.
2. Install the phototube (7) on its base (8) such that the cathode plate of the tube faces the lens (if already not installed or loose). See that the phototube is sitting firmly in its base and is not inclined or loose.
3. Adjust the light source (1) such that light is parallel to the guide (2) and maximum lights falls directly on drawtube (4).
4. Slide the light source (1) to about 350 mm position. Set light switch (12) to medium intensity. The light should shine on the middle area of the phototube cathode plate as shown in figure 1. If required user can make slight adjustment in the position of phototube by moving it gently too and for in its base to get a maximum current display, while other conditions are not changed.
5. Cover the phototube chamber by screwing back its cover (5).
6. Put the lens cover to stop the light and check the dark current to ≤ 0.003μA. Now all parts of the instruments are tested and adjusted.
7. Now adjust the light source (i) to about 250 mm position (optional). Set light switch (12) at medium to maximum intensity and take reading as per procedure given.

EXPERIMENT 1

Determination of Planck's Constant

Theory:

It was observed as early as 1905 that most metals under influence of radiation, emit electrons. This phenomenon was termed as photoelectric emission. The detailed study of it has shown.

1. That the emission process depends strongly on frequency of radiation.
2. For each metal there exists a critical frequency such that light of lower frequency is unable to liberate electrons, while light of higher frequency always does.
3. The emission of electron occurs within a very short time interval after arrival of the radiation and member of electrons is strictly proportional to the intensity of this radiation.

The experimental facts given above are among the strongest evidence that the electromagnetic field is quantified and the field consists of quanta of energy $E= h\nu$ where ν is the frequency of the radiation and h is the Planck's constant. These quanta are called photons.

Further it is assumed that electrons are bound inside the metal surface with an energy $e\phi$, where ϕ is called work function. It then follows that if the frequency of the light is such that

$$h\nu > e\phi$$

it will be possible to eject photoelectron, while if $h\nu<e\phi$, it would be impossible. In the former case, the excess energy of quantum appears as kinetic energy of the electron, so that

$$h\nu = \frac{1}{2}mv^2 + e\phi \qquad (1)$$

which is the famous photoelectrons equation formulated by Einstein in 1905.

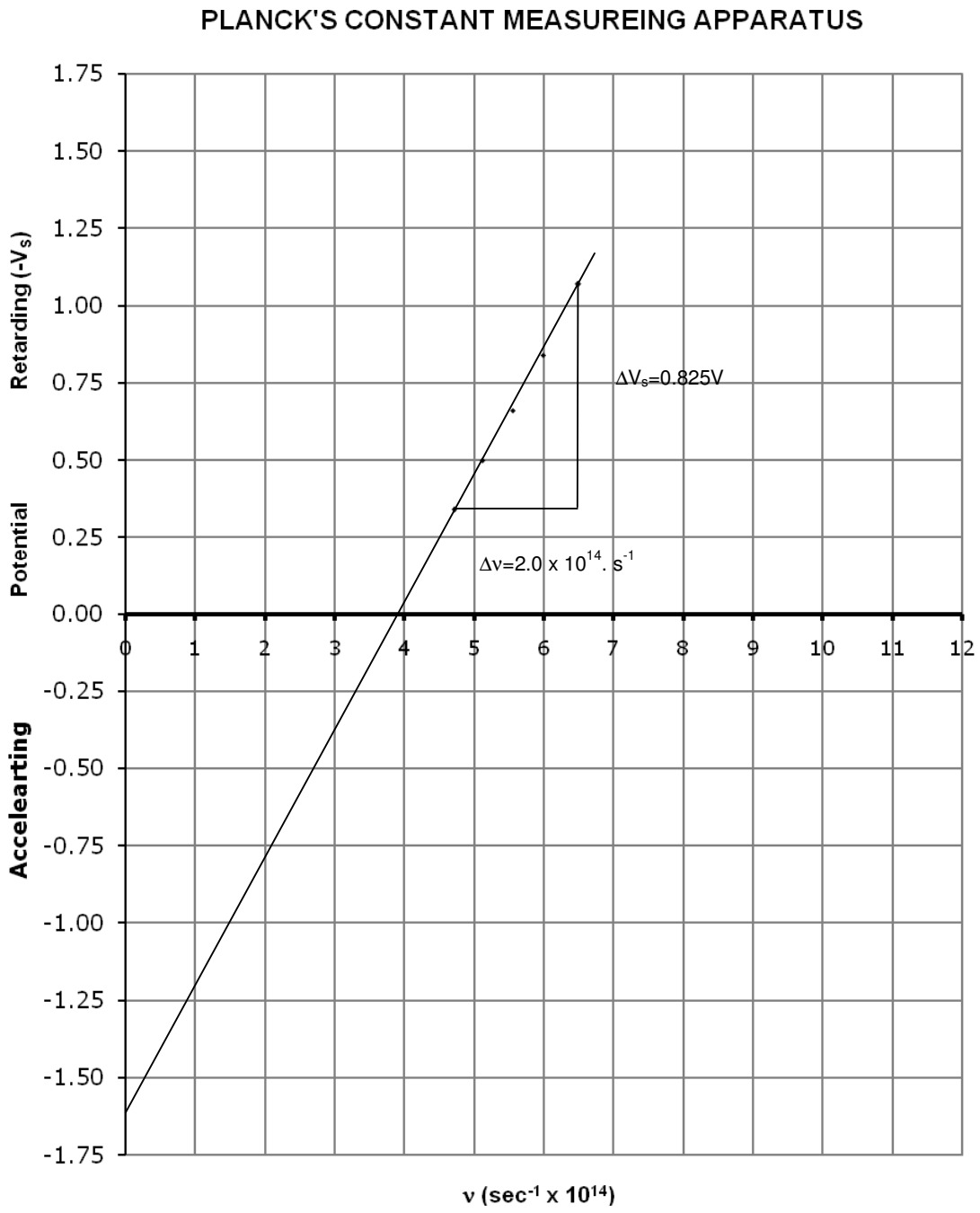
The energy of emitted photoelectrons can be measured by simple retarding potential techniques as is done in this experiment. Retarding potential at which the photo current stop, we call it stopping potential V_s and is used to measure kinetic energy of electrons E_e, we have,

$$E_e = \frac{1}{2}mv^2 = eV_s \qquad \text{or} \qquad V_s = \frac{h}{e}\nu - \phi$$

So when we plot a graph V_s as a function of ν, the slope of the straight line yields $\frac{h}{e}$ and the intercept of extrapolated point $\nu=0$ can give work function ϕ.

PROCEDURE

1. Insert the red color filter (635 nm), set light intensity switch (12) at strong light, voltage direction switch (14) at `-', display mode switch (10) at current display.
2. Adjust to de-accelerating voltage to 0 V and set current multiplier (4) at X 0.001. Increase the de-accelerating to decrease the photo current to zero. Take down the de-accelerating voltage (V_s) corresponding to zero current of 635 nm wavelength. Get the Vs of other wave lengths, in the same way.


PLANCK'S CONSTANT MEASUREING APPARATUS
Retarding (-Vs)
Potential
Accelearting
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
0
1
2
3
4
5
6
7
8
9
10
11
12
ΔVs=0.825V
Δν=2.0 x 10^14. s^-1
ν (sec^-1 x 10^14)

OBSERVATIONS

S. No	Filters	ν (sec^{-1} x 10^{14})	Stopping Voltage (V)
1	Red (635 nm)	4.72	- 0.34
2	Yellow I (585 nm)	5.13	- 0.50
3	Yellow II (540 nm)	5.56	- 0.66
4	Green (500 nm)	6.00	- 0.84
5	Blue (460 nm)	6.50	- 1.07

CALCULATIONS

Planck's Constant: $h = e\frac{\Delta V_s}{\Delta \nu}$

Where e is the charge of electron

By putting the value of ΔV_s & $\Delta \nu$ from graph

$$h = 1.602\times10^{-19} \times \frac{0.825}{2.00\times10^{14}}$$

$= 1.602 \times 10^{-19} \times 0.413 \times 10^{-14}$

$= 6.61 \times 10^{-34}$ Joules sec.

From Graph 1 intercept at $\nu = 0$ the value of

$\phi = 1.625$ V

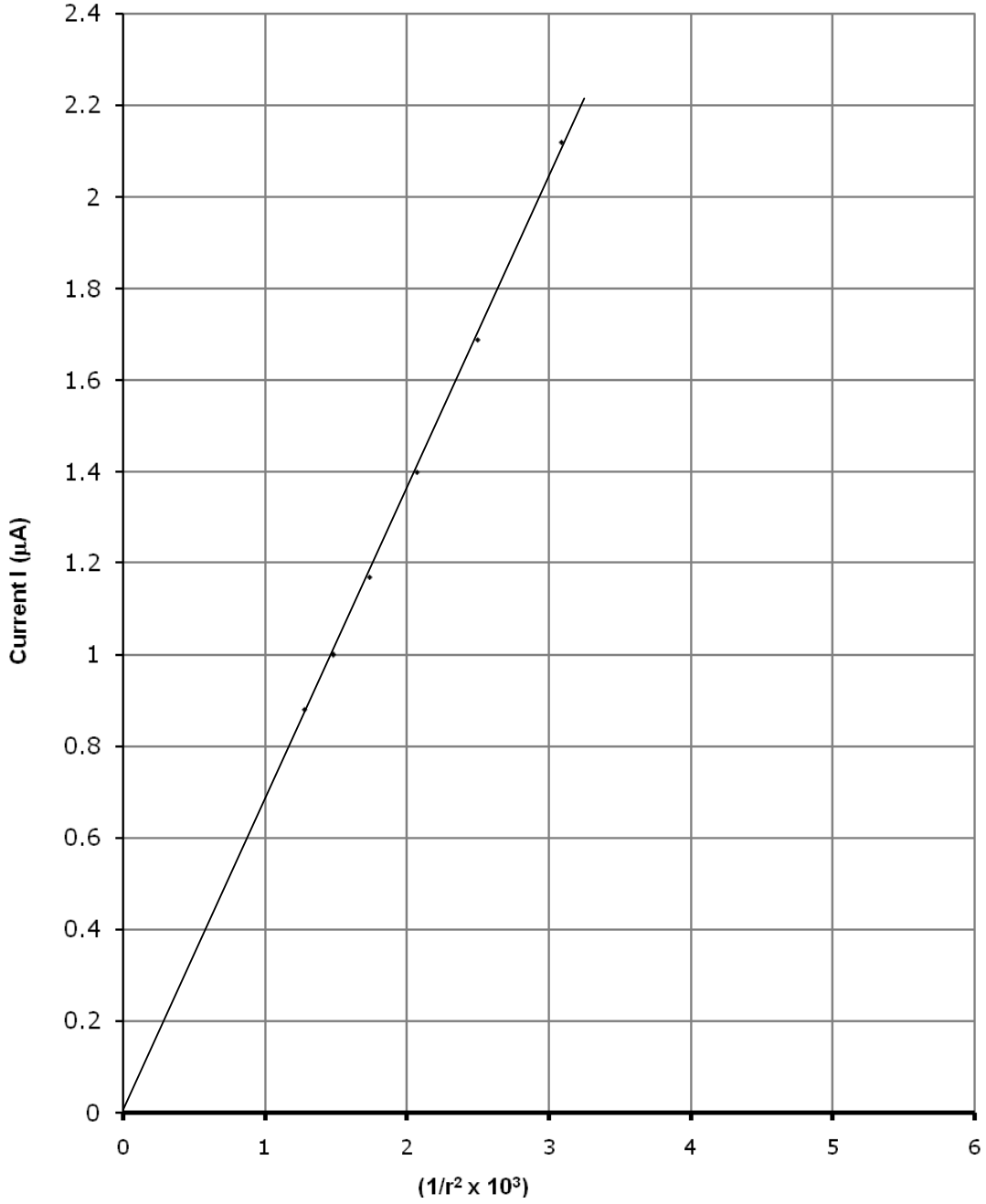
Compared with accepted value of $h = 6.62 \times 10^{-34}$ Joules. sec. the results are well within accepted error range.

PRECAUTIONS

1. This instrument should be operated in a dry, cool indoor space.
2. Phototube particularly should not be exposed to direct light, particularly at the time of installation of phototube; the room should be only dimly lit.
3. The instrument should be kept in dust proof and moisture proof environment, if there is dust on the phototube, color filter, lens etc. clean it by using absorbent cotton with a few drops of alcohol.
4. The color filter should be stored in dry and dust proof environment.
5. After finishing the experiment remember to switch off power and cover the drawtube (4) with the lens cover (15) provided. Phototube is light sensitive device and its sensitivity decreases with exposure to light, due to ageing.

VERIFICATION OF INVERSE SQUARE LAW

Graph : $1/r^2$ vs I



EXPERIMENT 2

To verify inverse square law of radiation using a photoelectric cell

Theory:

If L is the luminous intensity of an electric lamp and E is the luminescence (intensity of illumination) at point 'r' from it, then according to inverse square law.

$$E = \frac{L}{r^2}$$

If this light is allowed to face on the cathode of a photo-electric cell, then the photo-electric current (I) would be proportional to E.

$$E = \frac{L}{r^2} = K.I$$

Hence a graph between $\frac{1}{r^2}$ and I is a straight line, which verify the inverse square law of radiation.

PROCEDURE

(1) The connection would be same as before except a positive voltage would be applied to the anode with respect to cathode.
(2) Place a filter in front of the photoelectric cell.
(3) Keeping the voltage constant and position of photocell fixed, increase the distance of lamp from photo-cell in small steps. In each case note the position of the lamp r on the optical bench and the current I.
(4) The experiment may be repeated with other filters.

OBSERVATIONS & CALCULATIONS:

Filter red λ 6400 nm

Anode Voltage: 0.25 V

Reading of Photo-electric cell on the optical bench = 0 cm

S. No.	Distance between lamp and photo-cell (r)	$\frac{1}{r^2} \times 10^3\ cm^{-2}$	I μA
1.	18 cm	3.09	2.12
2.	20 cm	2.50	1.69
3.	22 cm	2.07	1.40
4.	24 cm	1.74	1.17
5.	26 cm	1.48	1.00
6.	28 cm	1.28	0.88
7.	30 cm	1.11	0.78

Graph between $\frac{1}{r^2}$ taken along the X-axis and I along the Y-axis is a straight line proving the inverse square law of radiation.

PRECAUTIONS

1. This instrument should be operated in a dry, cool indoor space.
2. Phototube particularly should not be exposed to direct light, particularly at the time of installation of phototube; the room should be only dimly lit.
3. The instrument should be kept in dust proof and moisture proof environment, if there is dust on the phototube, color filter, lens etc. clean it by using absorbent cotton with a few drops of alcohol.
4. The color filter should be stored in dry and dust proof environment.
5. After finishing the experiment remember to switch off power and cover the drawtube (4) with the lens cover (15) provided. Phototube is light sensitive device and its sensitivity decreases with exposure to light, due to ageing.

TECHNICAL SUPPORT

Feed Back

If you have any comments or suggestions about this product or this manual please let us know. **SES Instruments Pvt. Ltd.** appreciates any customer feedback. Your input helps us evaluate and improve our product.

To reach SES Instruments Pvt. Ltd.

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* e-mail : info@sestechno.com; sestechno.india@gmail.com

Contacting for Technical Support

Before you call the SES Instruments Pvt. Ltd. Technical Support staff it would be helpful to prepare the following information:

- If you problem is with the SES Instruments Pvt. Ltd apparatus, note :
  - Model number and S. No (usually listed on the label at the backside of instrument).
  - Approximate age of the apparatus.
  - A detailed description of the problem/ sequences of events may please be sent by email or Fax.
- If your problem relates to the instruction manual, note;
  Model number and Revision (listed by month and year on the front cover).
  Have the manual at hand to discuss your questions.