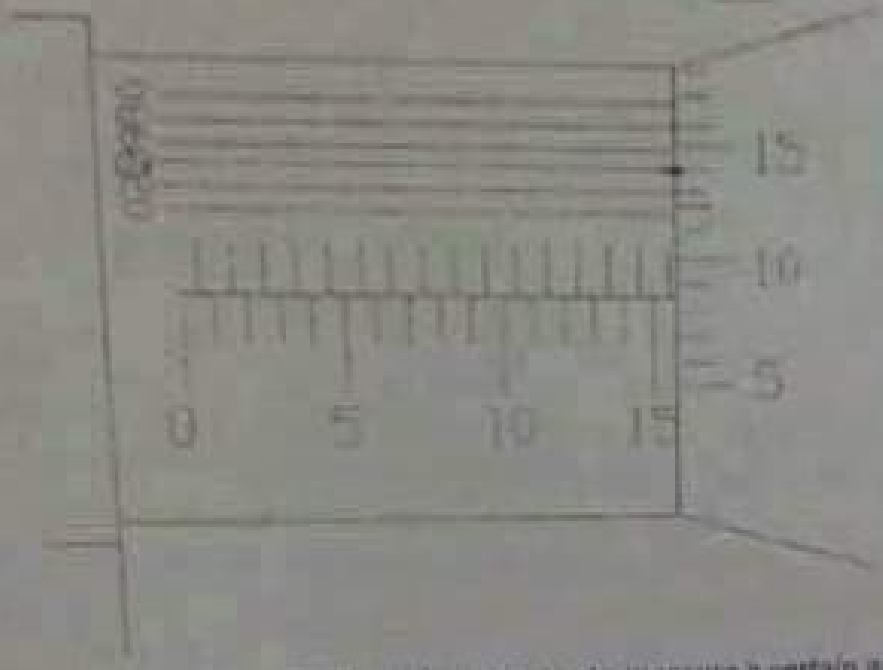
16 Points

A student used a vernier micrometer to measure a certain dimension. The diagram shows an enlargement of the micrometer scales. What reading was recorded?

Note: the dimensions on the sleeve are in mm.



16.34 mm = 163.4 mm

15.50 + 0.80 + 0.04 = 16.34

B. A student used a vernier bevel protractor to measure a certain angle. The diagram below shows the reading of the angle. What reading was recorded?

28° 15'

The reading of the angle is

Experiment 1 : Linear measurement

Accuracy = (division main scale) / (number of division on the vernier scale)

① Calipers → used to measure (thickness, distance, diameter)

* Vernier caliper - it is a precision instrument used to measure internal & external distances extremely accurate. (it has two scales : main scale and vernier scale)

* Dial caliper - it is a modified vernier caliper with gauges, allows us to have direct reading. It can also provided with digital indicator

→ For the metric dial : one revolution of the hand represents 2mm of travel and each dial graduation represents 0.02 mm max discrimination [other type 5mm more/rev → 0.05mm]

→ The beam scale on the dial is graduated only into 5mm and 10mm increment

→ the caliper dial is graduated into 100 dimensions.

NOTE : ABBE's principle → The maximum accuracy may obtain when the standard scale and the workpiece are aligned on the same Line measurement

② Micrometers → is a widely used device for measuring (thickness of blocks, outer and inner diameters and depth)

↳ have several over other measuring instruments :
- measures greater precision than calipers, but smaller ranges of lengths
- the micrometers gives more accurate readings than calipers

* Accuracy verification of a micrometer :
- zero-checking : is the condition where the display of a zero to one-inch micrometer should show zero
- Calibration : process of insuring the accuracy of gages (the process involve gage block and micrometer)
  ↳ If the reading you got from micrometer = gage block's dimension you may be

The types of micrometers :
1- External micrometers → used to measure wires, spheres, shafts, blocks
2- Internal micrometers → used to measure opening of holes
3- Depth micrometers → used to measure depths of slots and steps

Discussion :

Q1 : does varnier caliper conform to ABBE's law? NO, the varnier caliper doesn't conform

Q2 : Calculate the error of varnier caliper ? the reading error = $\frac{1}{20}$ = 0.05 mm

Q3 : what is the function of the sliding blade of caliper? permits the dial caliper to be used as an efficient and accurate depth

Q4 : what is a direct reading instrument ? does that apply to the caliper ? direct device are used to measure dimensions directly (there is no other reference devices)
→ the varnier caliper is a direct reading instrument.

Q:5 what are the source of error in reading a caliper ? Reading error / parallax error / error when transferring

Q6 : what could happen if the Locking screw is not used when measuring a distance ? the element will not be locked in position Leading to inaccurate reading

Q7 : Is the Reading taken from caliper of inside measurement is final? Sit considered as a comparator.
No yes it is final reading / we can consider it as comparator.

Q8 : Is the varnier Line standard or End standard ?
It is end standard

Experiment 3: Sine bar and angular measurement

Bevel protractor

① The plain bevel protractor → consists from main scale, movable arm and fixed nut.
- the main scale devided into 180 devisions each division = 1°
- the accuracy = ±05° and the total revolution can be measured = 180°

② Vernier protractor → the main scale divided into degrees from 0° to 90° each way
- and the vernier scale divided up to that 12 of the division occupying the same space as 23° on the main scale [1 vernier division = 23/12 = 1.92 degree on main scale]
- the device had movable arm, plate blade, fixed nut and vernier scale
[each division on the vernier scale represents 5' minutes]

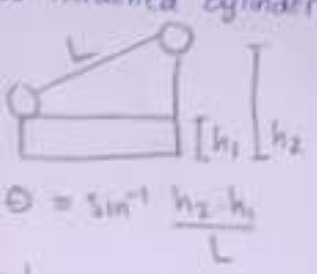
④ The clinometer → special case of the application of the spirit level
- the main use: the measurement of the included angle of two adjacent faces of a work piece
- how to use it ? ✱ the instrument base is placed on one face and the table body is adjusted until a zero reading of the bubble is obtained and the angle of rotation is then shown on an angular scale moving against an index
✱ a second reading is taken on the second face
- main scale = 360°
- Vernier scale: full revolution = 1° = 60 min, so each division on vernier scale = 1 min

⑤ Sine bar → it is a hardened steel beam mounted on two hardened cylinders

$$\sin\theta = \frac{\text{side opposite the angle}}{\text{Hypotenuse}}$$

$\theta = \sin^{-1}\frac{H}{L}$

probable error $d\theta = \pm\left(\frac{dH}{H} + \frac{dL}{L}\right)\tan\theta$



$\theta = \sin^{-1}\frac{h_2 - h_1}{L}$

⇒ To insure that the compound angle error is not introduced, the axis of the work must always be parallel to the axis of the sine bar

Discussion :

Q: would you use the sine bar for one component or on a production line ?

I would not use the sine bar for a production line because it would be difficult. using other equipment like clinometer or vernier protractor would be easier.

Experiment 2: Block Gauges → we use them when the maximum accuracy needed

* Block gauges → are practical length standards of industry.

(1) Line standard or Engraved scale → the unit length is defined as being the distance between engraved lines (like the ruler) (the whole distance is devided into sub units)

(2) End standard → the unit of length is defined as being the distance between the end faces of the standard (the form of either slip) → (it is more accurate) ✱

our experiment is talking about Gauge blocks → they are good examples of end standard

→ Sets of standard blocks or bars have the desired measurement, we use them to build a specific length

→ The characteristics of Gauge blocks: ① they are highly accurate

② they have a built in datum (their faces are flat and parallel)

③ the accuracy of end and line standards affected by the temperature → They are calibrated at 20°c

④ They are made in high grade cast steel

* Standard Block gauges: ① made of hardened steel and it is heat treated

② the accuracy = 0.0005 mm ③ 20°c & 1 atm & 60% relative humadity (calibrated conditions)

→ they have some characteristics:

① Straightness →

② Flatness → the surfaces made by the (lapping) process

③ parallelism → each two surfaces or two lines are parallel to a very high degree

* grades of gauge blocks:

1- 00

2- Calibration → provides highest level of accuracy

3- 0

4- I

5- II

- ✱ when the grades get larger the tolerance get larger and the price cheaper
- ✱ the best and most expensive is grade 00

Discussion:

Q1: why do we always choose the minimum number of block?

we want to minimize the tolerance and error to make the measurement more accurate (more blocks = more errors) the minimum blocks the more accuracy and precision.

Q2: why do we care about how the blocks should be attached to other?

because block used to calibrate other devices, we want to obtain accurate and true result Also, the blocks shall be placed at right angles and wiring them with a rotary motion to reduce the amount of surface rubbing

Q3: Suggest applications for block gauges?

they are the main means of length standardization used by industry

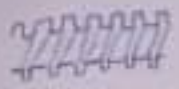
they are used as a reference for the calibration of measuring equipment such as (micrometers, sine bars, calipers, and dial indicators)

Experiment 4 : Screw Thread Inspection

* thread pitch = axial distance from one thread groove to the next groove along the same line
(p is measured by steel rule, caliper or comparator)

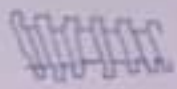
$p = \frac{\text{number of thread counted}}{\text{Length}}$

* left hand Thread



(most common / clockwise handle rotation)

* right hand Thread



* pitch diameter = effective diameter = the diameter at which the thread tooth and space are equal

$Ed = T + 2x$

$T = D_c + (R_{th(wire)} - R_{c(wire)})$

$2x = \frac{p}{2}\cot\theta - d(\operatorname{cosec}\theta - 1)$

d → wire diameter

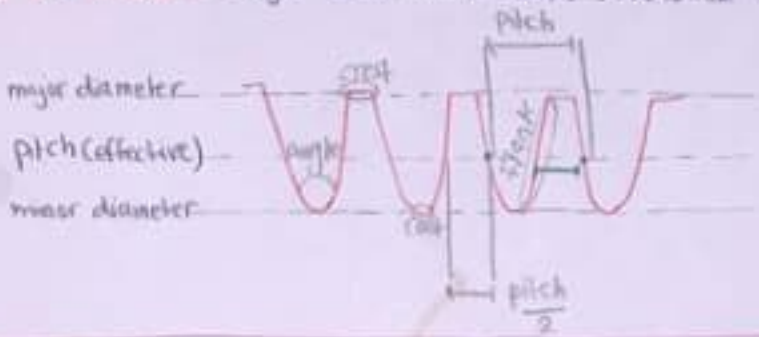
* major diameter (can be measured by micrometer, caliper or steel rule)
(it is good to measure the major diameter over the least used section of the screw)

major $D_{th} = D_c + (R_{th} - R_c)$

* minor diameter = the diameter that just touches the root of an internal thread

minor $D_{th} = D_c + (R_{th(prism)} - R_{c(prism)})$

* The crest of the thread = prominent part of the thread, whether internal or external
* The Root = the bottom of the groove between the two flanking surfaces whether internal or external
* The Flanks of the thread = the straight sides that connect the crest and root
* The angle of the thread = angle between the flanks, measured in an axial plane section



Discussion :

Q1: Why we are taken comparative measurement ?

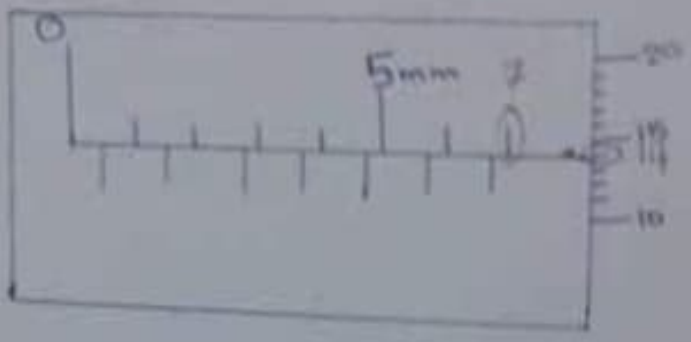
In comparative measurement we are trying to find the relative scale of any part of the

Q2: The designed accuracy of the floating carriage micrometer ?

accuracy = 0.5/250 = 0.002 mm

Q3: what are the advantages of Reduced & non Rotating micrometer spindle ?

- They are very durable because of their baked enamel frame and tungsten carbide faces
- They are very long lasting and unlikely to need replacing or repairing



$\Rightarrow$ 7.14 mm

What size is the gauge block build-up used with a 10 inches sine bar to set the work piece at an angle of 4° 30′? Show your calculations

$\sin\theta = \frac{h}{L} \Rightarrow \boxed{h = \sin\theta * L}$

Describe the working principle of the Auto Collimator?

The Auto Collimator is an optical device used to measure small angles with very high sensitivity. The Auto Collimator projects a beam of collimated light. An external reflector reflects all or part of the beam back into the instrument where the beam is focused and detected by a photodetector

3

the Auto Collimator measures the deviation between the

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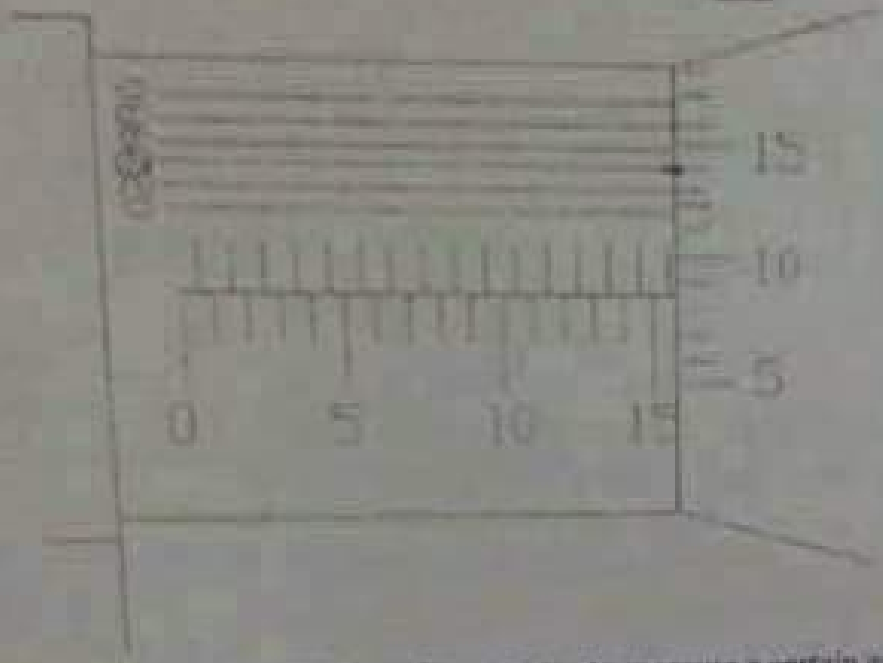


16.34 mm = 163.4 mm

2

15.50 +
0.80
0.04
16.34

B. A student used a vernier bevel protractor to measure a certain angle. The diagram below shows the reading of the angle. What reading was recorded?

28° 15'

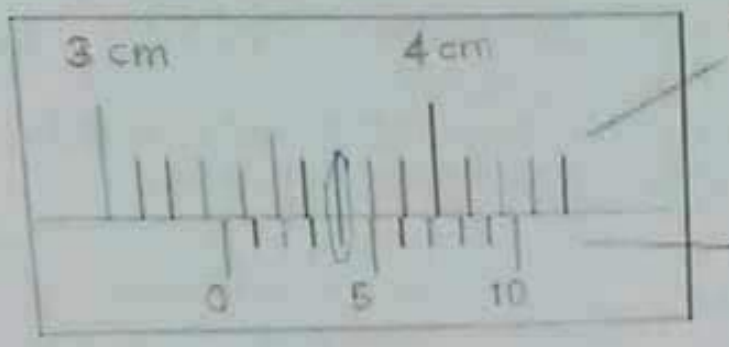
4

The reading of the angle is

Question 2: (12 points)

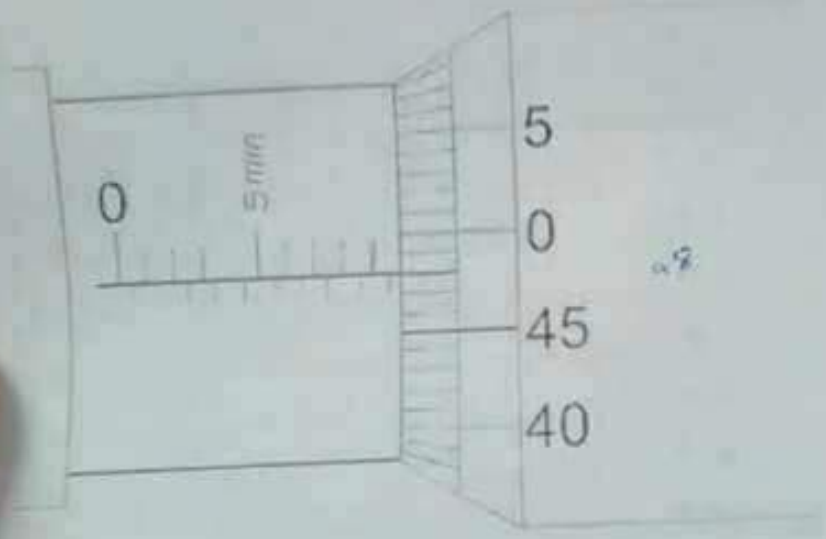
Fill in the space:

A. The reading of the following vernier caliper is 3.34 cm, and the accuracy is 0.05 mm



3.3
0.04
3.34

B. The reading of the following micrometer is 9.28 mm and the accuracy is 0.1 mm



C. The reading of the following vernier bevel protractor is 49° 20', and the accuracy is 0.05

Question 2:-

A. 3.34 cm .01 cm → vernier caliper

B. 9.5
+ .48

9.98 mm

.01 mm → micrometer

C. 50° 20' 5' (5 minute)

Q1) Does the external micrometer obey Abbe's Principle ?

Q) state the diff b/w end standard & line standard & why end standard more accurate ↳[Gauge block]

ans) in line stand, the unit length is defined as being the distance suitably engraved lines, while in end stand, unit of length is defined as being the distance b/w the end faces of the stand.
end stand is more accurate because the whole piece can measure same for ~~while stand only ...~~

Q3) why we choose the min number of block combination?

ans) to have the least error & for accurat reading

end stand measurement & calibration
- → high accuracy
- → have a built in datum becuz their measuring faces are flat & parallel

---

Gauge characteristic :-

1) straightness
2) flatnes
3) parallelism

Q4) diff b/w different grades of blocks:-

when the grades get larger the tolerance get larger & price cheaper → most expensive grade 00

Q5) What is the accuracy of gage block

the accuracy is 0.0005 mm depend on the smallest division measure

Question 1 :-

A. $\sin\theta = \frac{h}{L}$ → $h = \sin(4.5°) \cdot 5$

$h = .392"$

$L = 5$ inches

$\theta = 4° 30' = 4.5°$

B. 1.654 cm **1.64 cm**

C. 7.14 mm

D.
$$\begin{array}{r} 47.765 \\ -\ 1.005 \\ \hline 46.760 \\ -\ 1.26 \\ \hline 45.50 \\ -\ 20.5 \\ \hline 25.0 \\ -\ 25 \\ \hline \end{array}$$

using the following gauge blocks :-

1.005
1.26
20.5
25.0

} 4 gauges blocks

A. 15.584 mm

B. 28° 15'

that add all reading to set the measurment of all angles

) write two application of gage block :-

1) Provide a refelence for direct Measurment of distances b/w parallel surfaces
2) used in Angular measurment such as sine bar

9- the most common thermometers in real life Applications:

All "Thermocouples, RTDs, Thermistors"

10- which of the following are manufactured using Sensing element: RTDs

11- which of the following are more common: ⟸ ما بعرف، هو الحل الخيارات

RTDs - Thermistor - Thermometers - Themocouple

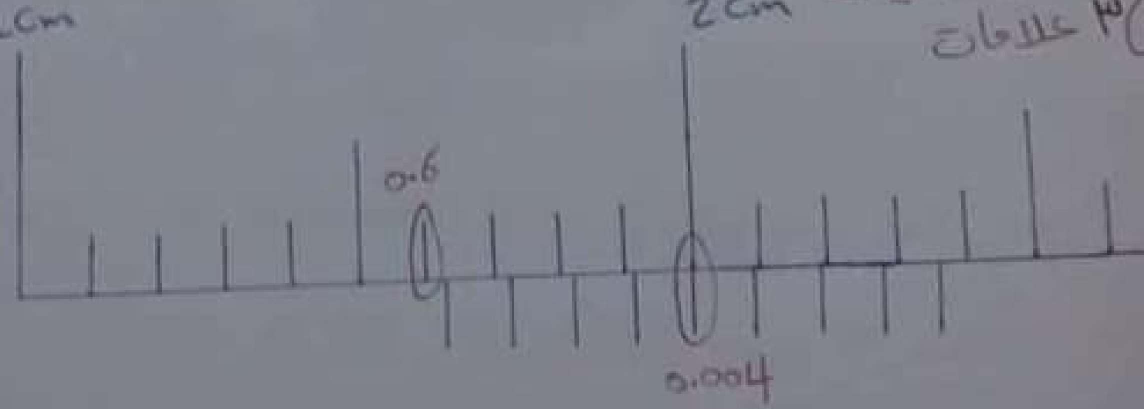
12- specification of Applications in thermometers: بس هيك متذكر من السؤال

13- In thermocouple a small open-Circuit Voltage are produce which the Voltage Value equal: الله أعلم بالسؤال وبإجاباته

14- !!strain gage بال sensor اشي عن ال!!

٣ أو ٤

٣ علامات (٣ السؤال الثاني بـ ⟵



⟹ 1.64 Cm

2

Q2) Does the external micrometer obeys Abbe's principle?

Yes, High accuracy must be given when the standard scale & the workpiece ~~must~~ required are aligned on the same line of measurement. because the standard scale & the wp are aligned

Q2) Does the caliper conform abbe's principle?

No, as we carried out the measurment procedure we can't allign the scale & the wp

Q3) errors in reading caliper:?

human error, zero error, alligament error

Q4) vernier → line standards
gauge blc → end standard

Q5) vernier > micrometer → measure both thickness, inside diameter & depth

Student name:-[redacted] Student no.-[redacted] Section: ----------

Question 1: (4 points)

Select the best answer for each of the following paragraph

1. We can use the gauge blocks to check the calibration of the vernier caliper or the micrometer
   A. True B. False

2. In the vernier caliper the size of division on the main scale is always greater that the size of division on the vernier scale, and the difference between the two values equal the size of division on the main scale divided by the number of divisions on the vernier scale.
   A. True B. False

3. In the vernier caliper the size of division on the main scale is always greater that the size of division on the vernier scale, and the difference between the two values equal the accuracy of the device.
   A. True B. False

4. When measuring a dimension using the micrometer the workpiece is fixed between two parts of the micrometer (the anvil and the spindle), the spindle is the fixed part of the micrometer, while the anvil is the movable part.
   A. True B. False

Question 2 (6 points)

Fill in the space

1. The reading of the following vernier bevel protractor is ---45° 45'---, and the accuracy is ---5min---

2. If the smallest division on the main scale of a vernier caliper is 0.5 mm and the number of divisions on its vernier scale is 25 divisions, then the accuracy of the device is ---0.02--- mm, and the error of the device is ---0.25--- mm

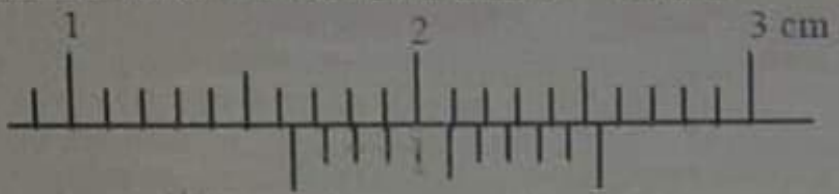
Question 1: **10 points**

A. What size is the gauge block build-up used with a 5 inches sine bar to set the workpiece at an angle of 4° 30'? show your calculations (3 points)

$\theta = 4.5^\circ$ $\quad$ $L = 5 \text{ inche} = 12.7 \text{ cm}$

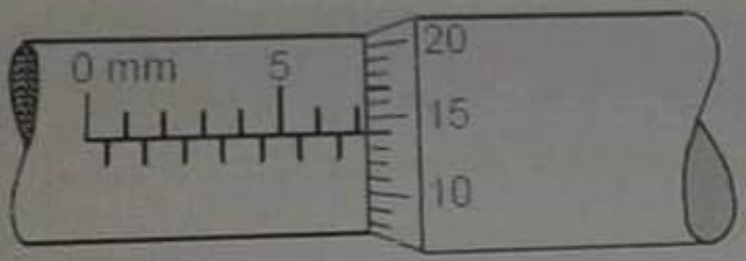
$\sin\theta = \frac{h}{L} \Rightarrow h = \sin 4.5^\circ \times 12.7 = 0.9996 \text{ cm} = 0.393 \text{ inch}$

B. A student used a vernier caliper to measure the diameter of a cylinder. The diagram shows an enlargement of the caliper scales. What reading was recorded? (2 points)



11 mm + 0.1 × 4 = 11.4 mm

C. What is the reading of the following micrometer? (2 points)



7 mm + 0.14 mm = 7.14 mm

D. Using the following set of gauge blocks, what is the minimum number of blocks to be wrung together to produce an overall dimension of 47.765 mm

Show your calculations (3 points)

Metric 103 pieces	
	Increment
1 piece (1.005) mm	
49 pieces (1.01-1.49) mm	0.01 mm
49 pieces (0.5- 24.5) mm	0.5 mm
4 pieces (25-100) mm	25 mm

47.765
① 1.005
46.760
② 1.26
45.50
③ 0.5
45.0
④ 25.00
20.00
⑤ 20.00
0.00

we need 5 block gauge

Question 2: (14 points)

A. Describe with a simple sketch the working principle of the autocollimator. (6 points)

B. Describe the working principle of the clinometers (4 points)

C. Does the external micrometer obeys to the Abbe's Principe? Explain. (4 points)

Question 3: (4 points)

A. Using the following set of gauge blocks, list the minimum number of blocks to produce an overall dimension of 76.575 mm. (show your calculations)

Metric (103) pieces	
	Increment
1 piece (1.005) mm	0.01
49 pieces (1.0) to 1.49) mm	0.5
49 pieces (0.5 to 24.5) mm	25
4 pieces (25- 100) mm	

B. Write two applications of block gauges

Question 3: (4 points)

Using the following set of gauge blocks, list the minimum number of blocks to produce an overall dimension of 100.995 mm. (show your calculations)

Metric (103) pieces	Increment
1 piece (1.005) mm	
49 pieces (1.01 to 1.49) mm	0.01
49 pieces (0.5 to 24.5) mm	0.5
4 pieces (25- 100) mm	25

100.995
1 .005
99.99
1.49
98.5
24.5
74.00
24.00
50.00
- 50.00
0 0

3/4

98.9
- 1.49
98.5 = 24.5

B. Why do we always choose the minimum number of blocks combinaton?

because accuracy Reading end standard measurment & calibration

6/6

Question 4: (6 points)

Describe the working principle of the clinometer

Colominitor its device using for angular measurment how face aligned for each other put the colominar on face check the reading of Bubble equal zero if not you have more knap and reverstal untill the Bubble gives zero reading colominator consis of two scale main scale in degree vernier scale The reading in second by reverse work pices after that add all resar to set the movement of all alligned measure angle

Question 4: (4 points)

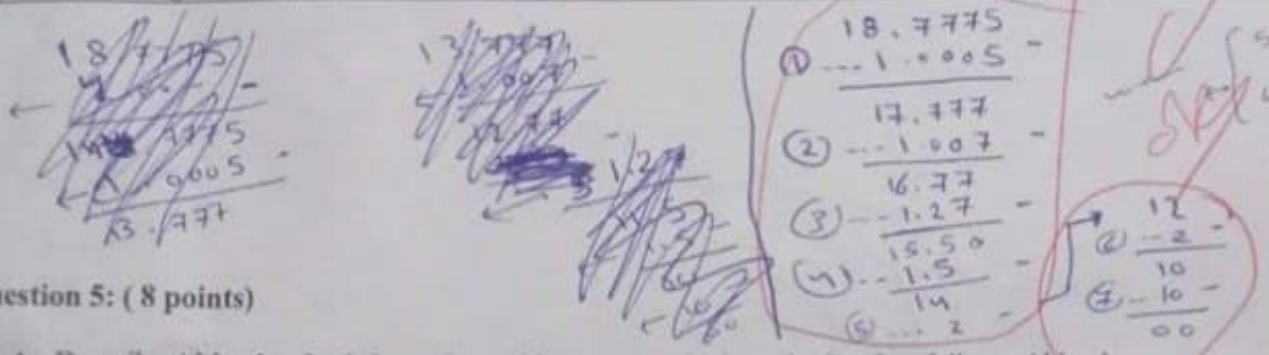
What is the minimum number of blocks that will be used to produce an overall dimension of 18.7775 mm. Show your calculations.

4/4

Note : remember to include the wearing blocks.

5 + 2 wearing blocks = (7)

	Pieces	Increment
One piece	1.0005	
9 pieces	1.001-1.009	0.001
49 pieces	1.01-1.49	0.01
19 pieces	0.5-9.5	0.5
9 pieces	10-90	10
2 pieces (wearing block)	2 mm each one	



Question 5: (8 points)

A. Describe **Abbes' principle**, and provide an example for a device that follows Abbes' principle. **(3 points)**

when the measured peace is aligned with the axial dimension of the device the accuracy becomes higher . Example : [external micrometer]

3/3

B. Compare between line standard and end standard devices. **(2 points)**

line Standards : the distance between two Parallel lines.

end Standards : the distance between two Parallel Surfaces

C. Describe the working principle of the clinometer. (3 points)

it is a special case of Spirit level.

we put the device on the workpiece that has two adjusted faces to measure the angle. we adjust to make the bubble in the middle (to make the reading Zero) then we take our measures.

- main Scale in Degrees.
- Vernier in minutes.

- what are the advantages of vernier caliper over a micrometer ?

scales are easier to move
- more convenient and easier to use
- more adaptable
- greater ranges of lengths to measure
- able to measure thickness, length, diameter, depth in the same instruments

Q10: how many screw threads are in each micrometer ? the spindle has 2 threads

Q11: does the external micrometer obeys ABBE's law ? yes it obeys ABBE's law

Q12: what is the total length approached by the moving barrel when it rotates a complete revolution ? 0.5 mm

Q13: can micrometers be used as comparators ? yes it can be used

Q14: does the accuracy of micrometer depend on the accuracy of the screw thread ? yes

Q15: what are the sources of error in reading a micrometer ?

- parallax error = not looking perpendicular to the micrometer
- Excessive measuring force
- unclean micro meter
- over tightening the micro meter

Q16: Is the spindle rotating or non-rotating ? Name disadvantages of rotating type ?

- it is rotating
- the disadvantages (more expensive, rotating head type exerts a twisting action on work piece)

Question 3: (8 points)

A bench micrometer was used to measure the dimensions for an external thread; the readings are given as:

The reading over the thread =	9.6270 mm
The reading over the cylinder =	9.7166 mm
The reading over the thread (with wires) =	10.0716 mm
The reading over the cylinder (with wires) =	13.2788 mm
The reading over the thread (with prisms) =	11.9306 mm
The reading over the cylinder (with prisms) =	15.5414 mm

8/8

And you know that the diameter of the standard cylinder is equal to 15.0000 mm ,the flank angle of the thread $(\theta) = 30^0$, the diameter of the wire $(d) = 2.0207$ mm , and the pitch size of the thread $(p) = 3.5\,mm$

The effective diameter equation is

$D_{eff} = T + \frac{p}{2}\cot\theta - (cosec\,\theta - 1) * d$

where T is the dimension under the wires

$D_c = 15\,mm$
$d_{wire} = 2.0207\,mm$
$P = 3.5\,mm$
$\theta = 30^\circ$

Calculate the major diameter, the minor diameter, and the effective diameter of the thread. (Show your calculations)

① major D $= D_c + (R_{th} - R_c)$
$= 15 + (9.6270 - 9.7166)$
$= 14.9104\,mm$

② minor D $= D_c + (R_{th(prisms)} - R_{c(prisms)})$
$= 15 + (11.9306 - 15.5414)$
$= 11.3892\,mm$

③ effective $D_{eff} = T + \frac{p}{2}\cot\theta - d\,(cosec\,\theta - 1)$

$T = D_c + (R_{th(wires)} - R_{c(wires)})$
$= 15 + (10.0716 - 13.2788)$
$= 11.7928\,mm$

$= 11.7928 + \frac{3.5}{2}\cot 30 - (2.0207)(cosec\,30 - 1)$
$= 12.8032\,mm$

Question 2: (14 points)

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49 pieces (0.5 to 24.5) mm	0.5
4 pieces (25 -100) mm	25

B. Write two applications of block gauges