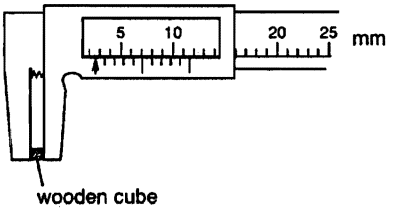
TOPIC 1 Physical Quantities and Units

1.1 Physical Quantities
1.2 SI units 1.3 Prefixes
1.5 Measurement of length and time

1 The diagram shows a wooden cube being measured using vernier calipers.

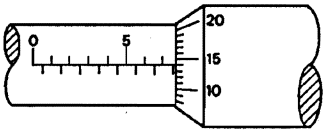


What is the width of the cube, as recorded by the vernier scale?

A	1.6 mm	**D**	11.3 mm
B	2.6 mm	**E**	13.3 mm
C	8.0 mm		J90/I/1; J96/I/2

2 The diagram shows a micrometer.

What reading is shown?



A	5.14 mm	
B	5.64 mm	
C	7.14 mm	
D	7.16 mm	
E	7.64 mm	N90/I/1

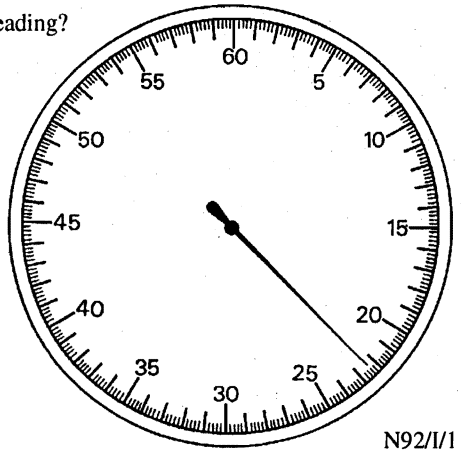
3 Which instruments are most suitable for the accurate measurement of the thickness of a coin and the internal diameter of a test-tube?

	coin thickness	*test-tube internal diameter*	
A	micrometer	rule	
B	micrometer	vernier caliper	
C	rule	micrometer	
D	rule	vernier caliper	
E	vernier caliper	micrometer	J91/I/1

4 A stopwatch hand stops in the position shown.

What is the reading?

A	21.2 s		
B	22.4 s		
C	27.6 s		
D	32.0 s		
E	38.0 s		

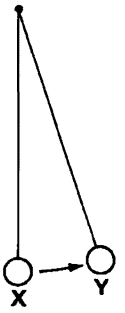


N92/I/1

5 Which of the following is measured using a micrometer?

A	area	**D**	length
B	current	**E**	mass
C	force		J93/I/1

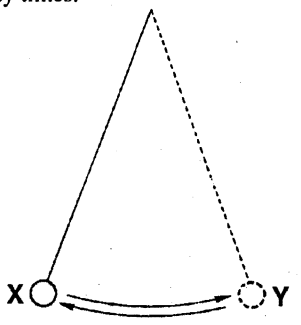
6 The time taken for a pendulum to swing from the rest position **X** to its maximum displacement **Y** is 1.5 s.



What is the period of the pendulum?

A	1.5 s	**D**	6.0 s
B	3.0 s	**E**	7.5 s
C	4.5 s		J93/I/2

7 It takes 13.8 s for a pendulum to swing from **X** to **Y** and back again twenty times.

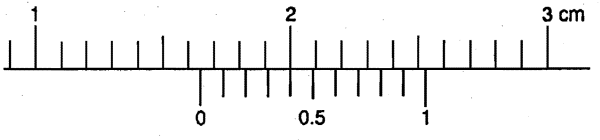


What is the period of the pendulum?

A	0.345 s	**D**	4.60 s
B	0.690 s	**E**	13.8 s
C	1.38 s		N93/I/2

8 A student used a vernier caliper to measure the diameter of a wooden cylinder.

The diagram shows an enlargement of the caliper scales.



What reading was recorded?

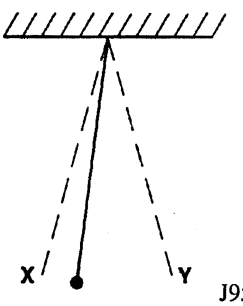
A	2.40 cm	**C**	0.62 cm
B	1.64 cm	**D**	0. 42 cm

N94/I/1

9 The bob of a simple pendulum is swinging between points **X** and **Y**.

It takes 8.6 s to swing from **X** to **Y** and back to **X** ten times.

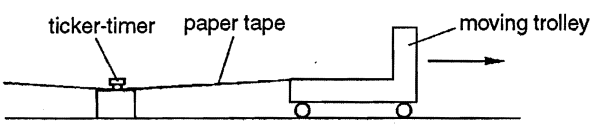
What is the period of the pendulum?



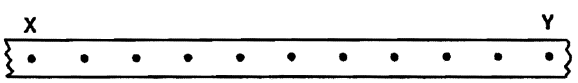
A 0.43 s
B 0.86 s
C 4.3 s
D 86 s

J95/I/1

10 A pupil uses a ticker-timer to investigate the movement of a trolley.



Every second, the ticker-timer puts 60 dots on the piece of tape. The tape looks like this.

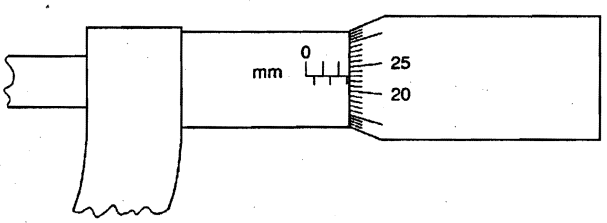


What length of time is shown between **X** and **Y** on the tape?

A 0.10 s
B 0.11 s
C 0.17 s
D 0.18 s

N95/I/1

11 The diagram shows a micrometer.



Which reading is shown?

A 2.23 mm
B 2.73 mm
C 3.23 mm
D 5.23 mm

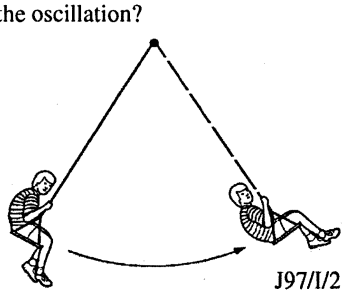
J97/I/1

12 The diagram shows a child on a swing.

The child makes 10 complete swings in 30 seconds.

What is the frequency of the oscillation?

A $^1/_{10}$ Hz
B $^1/_3$ Hz
C 1 Hz
D 3Hz



J97/I/2

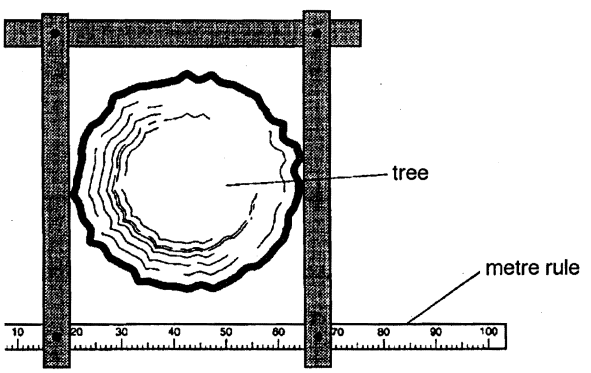
13 A student has been asked to calculate the volume of a piece of wire, which is about 80 cm long and about 0.2 cm in diameter.

Which measuring instruments should the student use?

	length	*diameter*
A	metre rule	micrometer
B	metre rule	vernier calipers
C	micrometer	vernier calipers
D	vernier calipers	micrometer

N97/I/1

14 The diagram shows how the diameter of a tree might be measured.

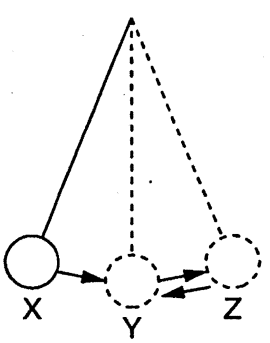


What is the diameter of the tree?

A 45 cm
B 50 cm
C 55 cm
D 65 cm

J98/I/1

15 The diagram shows a pendulum oscillating between positions X and Z. It takes 1.5 s to go from X to Z and back to the mid-point Y.



What is the period of the pendulum?

A 0.5 s
B 1.0 s
C 1.5 s
D 2.0 s

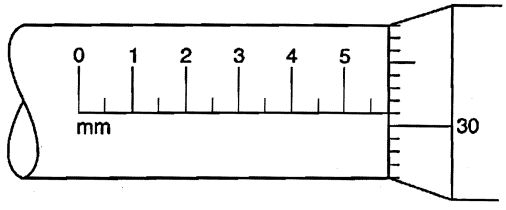
J98/I/2

16 Which physical quantity is measured using a micrometer?

A current
B length
C time
D weight

N98/I/1

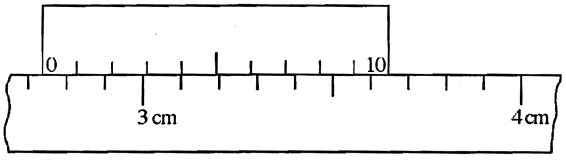
17 The diagram shows part of a micrometer screw gauge.



What is the reading shown?

A 5.31 mm
B 5.79 mm
C 5.81 mm
D 6.31 mm N91/I/2; J94/I/1; J99/I/1

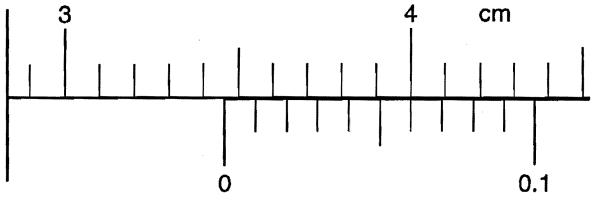
18 The diagram shows part of the vernier scale on a pair of calipers.



Which reading is correct?

A 2.74 cm **C** 3.26 cm
B 3.10 cm **D** 3.64 cm N99/I/1

19 The diagram shows a vernier scale.

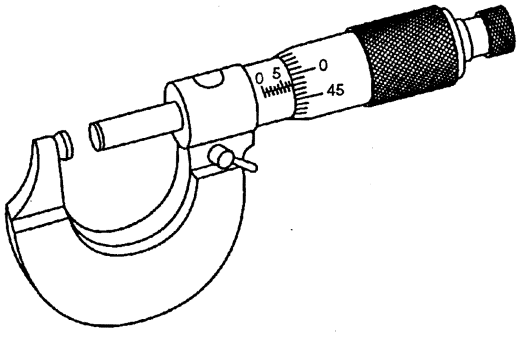


Which reading is shown?

A 3.44 cm **C** 3.60 cm
B 3.46 cm **D** 4.00 cm J2000/I/1

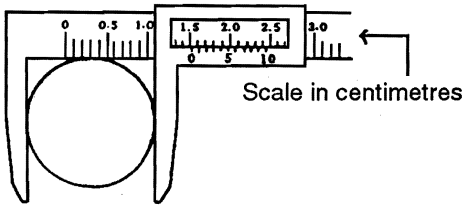
20 The diagram shows a micrometer screw gauge.

What is the reading shown?



A 5.25 mm **C** 7.02 mm
B 5.48 mm **D** 7.48 mm N2000/I/1

21 The diameter of a metal cylinder is measured using vernier calipers as shown in the diagram.



Write down the reading, in centimetres, for the diameter of the cylinder.

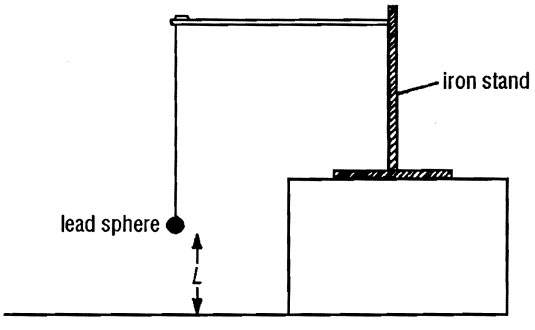
State **two** advantages of using these callipers compared with using a rule reading in millimetres for making this measurement. N79/I/1

22 A car track has two marker posts 50 m apart at one side of the track.

(a) Describe how an observer in a car could use a stop-watch to measure the time taken for the car to travel the distance between the posts.

(b) Give reasons why this measurement might be inaccurate in spite of using a stop-watch which records to 0.1 of a second. J80/I/1

23 A small lead sphere is suspended on a thin string from a stand so that the length of its suspension can be varied. The arrangement is indicated in the diagram below.



The distance L from the bottom of the sphere to the ground is measured and the sphere is pulled to one side through an angle of approximately 5° and released. It then swings from side to side carrying out oscillations.

The period T of such an oscillation is the time between the instants at which the bob passes a particular point in its swing *travelling in the same direction*. Describe in detail how you would measure L and obtain as accurately as possible a value for the period of these oscillations.

The timing is repeated for a number of different lengths of the string. *The support is kept fixed throughout.* The following values for T^2 and L are obtained.

T^2/ S^2	5.95	5.67	5.02	4.10	3.47	2.95
L/m	0.124	0.200	0.353	0.575	0.740	0.875

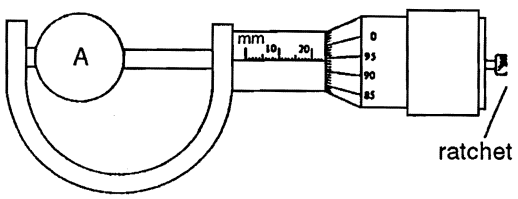
Plot a graph of T^2 against L. L is to be plotted along the x-axis with scale beginning at zero and extending to 1.0 m.

The scale for T^2 along the y-axis should be chosen to cover the range from 2.0 s^2 to 7.0 s^2.

Determine the gradient of your graph making clear the particular values of T^2 and L you have used. Also use your graph to deduce the height of the bottom of the bob above the ground to give a period of 2.5 s. J81/I/II/1

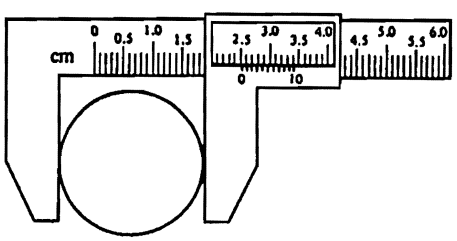
24 The figure shows an enlargement of a micrometer screw gauge set to measure the diameter of the ball bearing A.

Write down the reading of the gauge.



What is the purpose of the ratchet? N81/I/1

25 The diagram shows vernier calipers used to find the diameter of a circular coin. Write down the value given for this diameter.



What precautions would you take in order to make your determination as accurate as possible? N82/I/1

26 A simple pendulum is illustrated in Fig. 1 together with a metre rule which could be used to measure its length L.

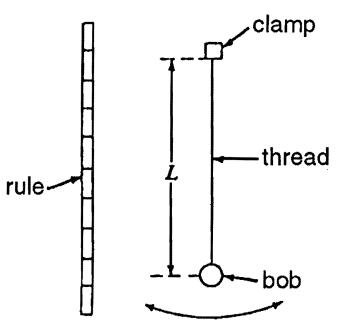


Fig. 1

Using a stop clock, Fig. 2, t, the time for 20 complete oscillations (swings) can be determined.

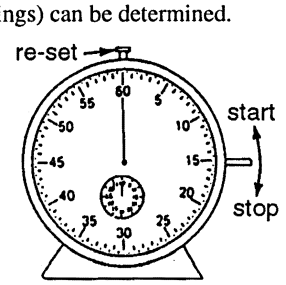


Fig. 2

In a simple pendulum experiment t, the time to complete 20 oscillations was determined so as to investigate how T, the time for *one* oscillation varied with L, the length of the pendulum.

(i) Construct a table, with headings, suitable for your laboratory note-book, in which *all* the observations made could be recorded and in which values for T could be shown.

(ii) For a pendulum for which the value of T is approximately 1 s why is it desirable to time at least 20 oscillations when using a stop clock which can measure only to the nearest 0.5 s? J86/I/II/4

27 *(a)* What is meant by the *period* of a simple pendulum?

(b) The period of a simple pendulum 1 m long is approximately 2 s. State clearly how you would determine the period of such a pendulum as accurately as possible, using a stopclock accurate to within 0.1 s. [6]
J91/II/1

28 Fig. 3 shows a simple pendulum suspended from a clamp.

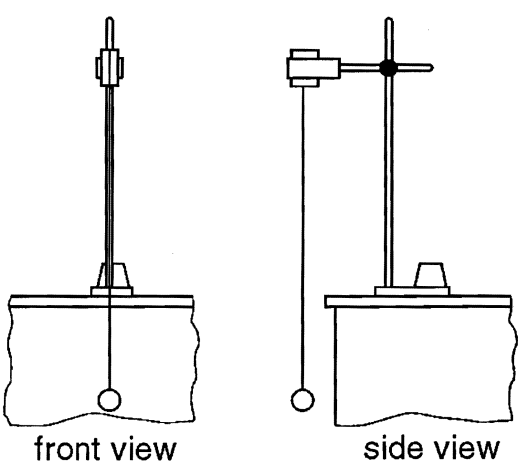


Fig. 3

(a) Describe briefly how you would use a stopwatch or a stopclock to determine, as reliably as possible, the period of oscillation of the pendulum. [3]

(b) A student obtains the following values for the time for 20 complete oscillations of a pendulum.

14.6 s 14.7 s 14.5 s 14.6 s 14.7 s

Determine the period of the pendulum. [3]
N97/I/1

1.4 Scalars & vectors

1 Which of the following is a vector quantity?

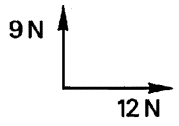
A energy
B mass
C temperature
D time
E velocity J90/I/6

2 Which of the following lists of physical quantities consists only of vectors?

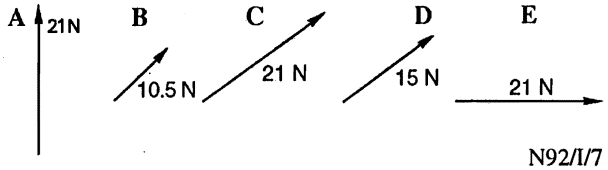
A acceleration, force, volume
B mass, velocity, acceleration
C time, mass, velocity
D velocity, acceleration, force
E volume, force, temperature

N90/I/6

3 The diagram shows a 9 N force and a 12 N force acting at right angles.



Which of the following diagrams shows the resultant force?



N92/I/7

4 A container holds $5m^3$ of a liquid whose density is 800 kg/m^3 at 20 °C. The weight of the container and the liquid is 45 000 N. It takes 300 s to empty the container.

Which of the following can be represented by a vector?

A 5 m^3
B 800 kg/m^3
C 20 °C
D 45 000 N
E 300 s

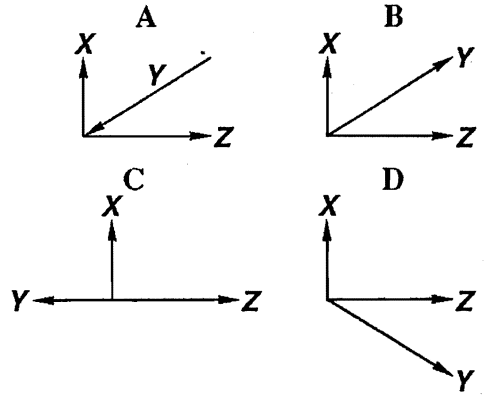
N93/I/7

5 Which of the following are correctly identified as a scalar and a vector?

	scalar	*vector*
A	force	speed
B	mass	temperature
C	time	acceleration
D	weight	velocity

N94/I/7

6 Which diagram represents the directions of vectors *X* and *Y* and their resultant *Z*?



N95/I/7

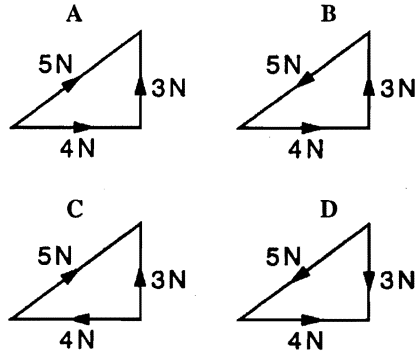
7 A vector contains more information than a scalar.

What is this extra information?

A acceleration
B direction
C resultant
D size

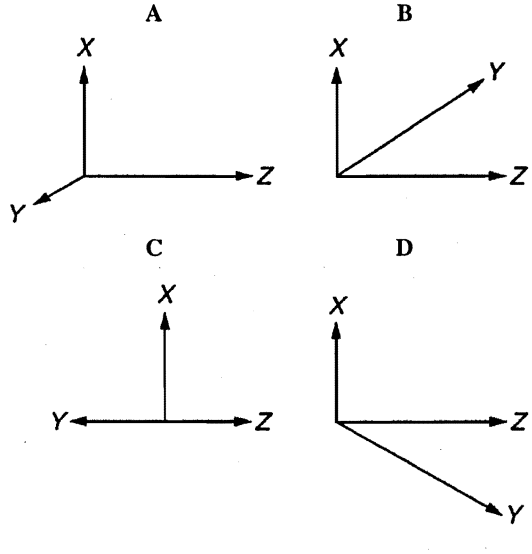
J96/I/8

8 Which diagram correctly shows the addition of the 4 N and 3 N forces?



N96/I/7

9 Which diagram represents the directions of vectors *X* and *Y* and their resultant *Z*?



J98/I/6

10 Which of the following lists only vector quantities?

A energy, mass and force
B energy, mass and power
C velocity, force and acceleration
D velocity, power and acceleration

N98/I/8

11 Which row correctly describes force, mass and acceleration as vector or scalar quantities?

	force	mass	acceleration
A	scalar	scalar	scalar
B	scalar	vector	scalar
C	vector	scalar	vector
D	vector	vector	vector

N99/I/8

12 Which of the following is a scalar quantity?

A the braking force needed to stop a car
B the effort needed to hammer a nail into wood
C the heat needed to boil some water
D the thrust needed to lift a rocket off the ground

N2000/I/8

13 A small aircraft may be considered to be acted on by three forces. The effective forward force is 6000 N and acts horizontally. The weight of the aircraft is 5000 N and the lifting force (acting vertically upwards) produced by the wings is 7000 N. Determine the magnitude and direction of the resultant force acting on the aircraft.

Magnitude _____

Direction _____ N79/I/2

14 Name **one** example of

(i) a scalar quantity,

(ii) a vector quantity.

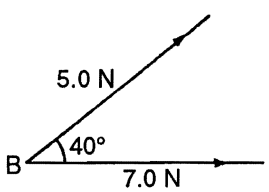
By reference to these examples, or otherwise, distinguish between scalar and vector quantities. N80/I/2

15 Why is *force* referred to as a vector quantity?

Two forces acting at a point have magnitudes 5 N and 8 N. Explain why their resultant may have any magnitude between 3 N and 13 N.

Forces of 7.0 N and 11.0 N act at a point so that the angle between their lines of action is 35°. By means of a scale diagram, determine the magnitude of the resultant of these two forces. J81/II/7

16 Two forces of magnitude 5.0 N and 7.0 N act on a small body, B. The angle between the directions along which the forces act is 40°, as illustrated in the diagram.

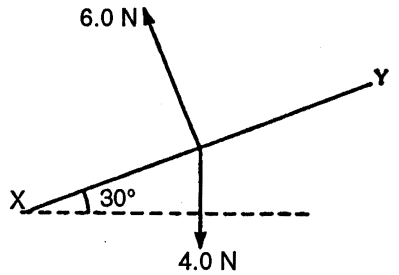


Determine the magnitude of the resultant force on the body B by completing diagram using a suitable scale.

State clearly the scale you have used. N81/I/2

17 A man travels 5.0 km due North from his starting point and then travels a further 8.0 km in a straight line in the direction 301 East of North. By means of a scale diagram, determine how far in a straight line he is from his starting point. State the scale of your diagram. J83/I/I

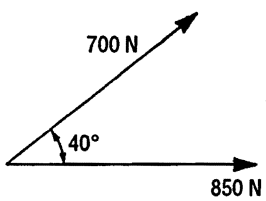
18 In the diagram, XY represents a flat kite of weight 4.0 N. At a certain instant, XY is inclined at 30° to the horizontal and the wind exerts a steady force of 6.0 N at right angles to XY so that the kites flies freely.



In the space to the right of the diagram, draw a scale diagram to find the magnitude of the resultant force acting on the kite and the angle to the horizontal at which the force acts.

N84/I/2

19 Two men attempt to move a small tree stump: they tie ropes to the stump and pull horizontally, one man exerting a force of 700 N and the other a force of 850 N, in the directions shown in the diagram above. By drawing a scale diagram in the space below, find the resultant force on the tree stump.

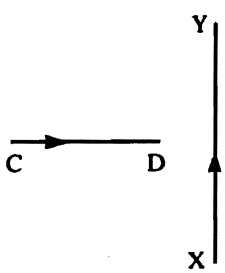


Scale used:

Magnitude of resultant force:

Angle between the direction of the resultant and the direction of the 850 N force: J85/I/2

20 The engine of a boat drives it through the water with a velocity 2.6 m/s in the direction XY shown in the diagram. The water flows with a velocity 1.2 m/s in the direction CD which is perpendicular to XY, as shown in the diagram. Use a scale diagram to determine the angle to XY at which the boat travels.

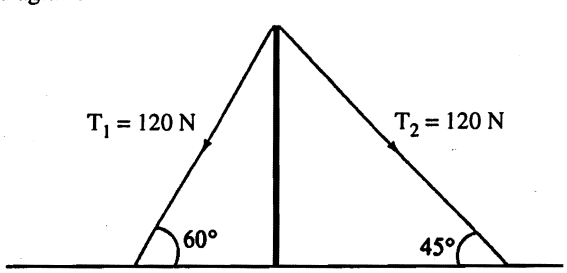


Scale used; .....

Angle to XY .....

N85/I/I

21 An aerial is held by wires; the tensions in two of the wires and the directions in which they act are as shown in the diagram.



By means of a scale diagram, determine the resultant force exerted on the aerial by the two wires.

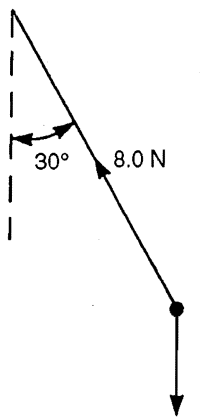
Scale used:

Magnitude of resultant:

Angle between direction of resultant and direction of T_1.

J86/I/2

22 A mass of weight 7.0 N hanging on the end of a string is pulled sideways so that the string makes an angle 30° with the vertical as shown in the diagram.



In this position the tension in the string is 8.0 N. By means of a scale diagram determine the resultant of the tension in the string and the weight of the mass.

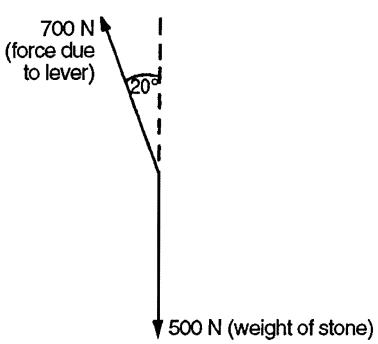
Show clearly on your diagram the direction in which the resultant acts and record its magnitude.

Scale: .....

Magnitude of resultant .....

N86/I/2

23 The diagram shows two of the forces acting through the centre of gravity of a large stone which is being raised by a man using a lever.



By means of a scale diagram, find the magnitude of the resultant of these forces.

Scale used .....

Magnitude of resultant force .....

J87/I/2

24 A large vessel is towed by two tugs which exert forces of 3500 N and 2500 N. The angle between the ropes from the tugs is 60°. By drawing a scale diagram, determine

(a) the resultant force exerted by the ropes on the vessel,

(b) the angle between the direction of this resultant force and the direction in which the pull of 3500 N is exerted.

State the scale used for your diagram. [5]

N87/II/7

25 A barge is pulled at a steady speed through still water by two horizontal cables as shown in the plan view below (Fig. 1), By means of a scale drawing in the space provided, determine the magnitude and direction of the resultant force exerted on the barge by the cables. State the scale you have used. [4]

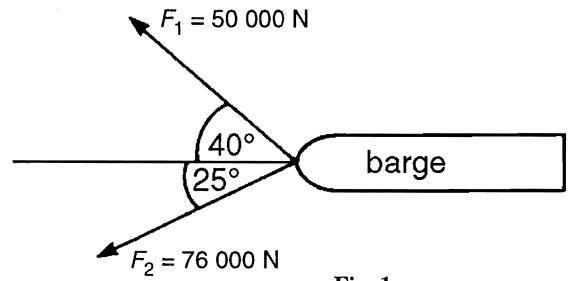


Fig. 1

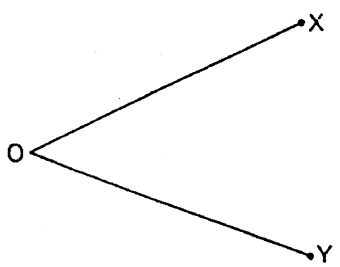
Scale used .....

Magnitude of resultant force .....

Direction of resultant force .....

J88/I/2

26 The ends of the rubber cord in the diagram below are firmly fixed at X and Y. The mid-point O of the cord is pulled into the position shown so that the angle between the two parts of the cord is 45° and the tension in each part of the cord is 25 N.



Make a scale drawing to determine the magnitude of the resultant force exerted by the cord on a small object placed at O. Show the direction of this resultant force by an arrow on your scale drawing. State clearly the scale you have used. [4]

Scale .....

N88/I/3

27 *(a)* Here is a list of physical quantities:

acceleration energy force mass weight

Which of these quantities is/are *vector* quantities? [2]

(b) An arrow is shot into the air at an angle to the horizontal. In the first 1.00 s of flight it moves 3.0 m vertically upwards and 4.0 m horizontally. Determine, by drawing or calculation, the magnitude and direction of the resultant velocity of the arrow at the end of the first second.

(i) Magnitude = ...

(ii) Direction = ... to the horizontal. [4]

J92/II/1

28 There are two kinds of quantities in physics, *scalars* and *vectors*.

(a) What is the difference between a vector quantity and a scalar quantity? [1]

(b) Give one example of a vector quantity and one example of a scalar quantity. [1]

(c) A student X, starting at a point **P**, walks due North for 1.00 h at a constant speed of 4.0 km/h and then, at the same constant speed, walks 4.0 km due East, finishing at a point **Q**. In the same total time but at a different constant speed, a second student Y walks directly from **P** to **Q**. Determine by calculation or by drawing,

(i) the total distance walked by student X,

(ii) the distance walked by student Y,

(iii) the velocity of student Y. [5]

N94/II/1

29 A student investigating balanced forces uses the apparatus shown in Fig. 2.1.

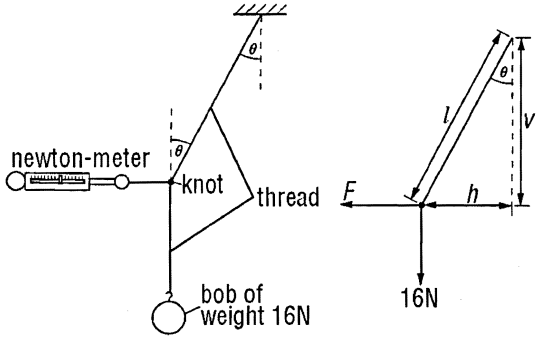


Fig. 2.1

Fig. 2.2

The student notices that θ the angle the upper part of the thread makes with the vertical, is 45° when the reading on the newton-meter is 16 N.

(a) (i) By drawing a vector diagram to scale, determine the magnitude and direction of the total force exerted on the knot by the bob and the newton-meter.

(ii) State the magnitude and direction of the forces exerted on the knot by the upper part of the thread. [3]

(b) In a further investigation, the student determines the variation of tan θ with the horizontal force F exerted by the newton-meter. The values obtained are given in the Table below.

tan θ	0.180	0.475	0.640	0.805	1.100
F/N	2	6	9	12	16

(i) Plot a graph of tan θ (y-axis) against *F/N* (x-axis). Draw the best straight line through your points.

(ii) Determine the gradient of your graph. [8]

(c) (i) Use your graph to determine the angle θ when F is 10 N.

(ii) Explain with the aid of Fig. 2.2 how you would obtain accurate values of tan θ using a metre-rule. [4]

J97/II/8

30 Fig. 3.1 shows a catapult used to project an object. Force F pulls back the object, creating tension in the rubber cords.

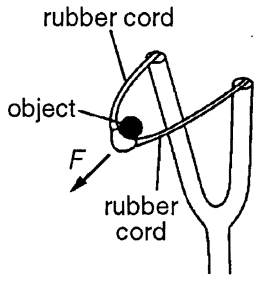


Fig. 3.1

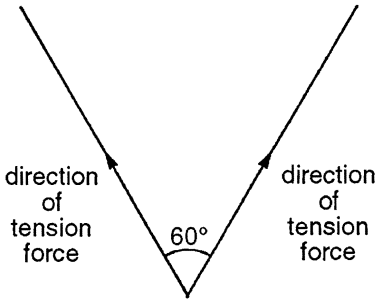


Fig. 3.2

(a) The tension force in each rubber cord is 20 N and the two cords are at 60° to each other. Fig. 3.2 shows the direction of the two tension forces acting on the object.

By making a scale drawing on Fig. 3.2, or otherwise, find the resultant of these two tension forces acting on the object. If you draw a scale drawing, state the scale that you use.

resultant force = ... [3]

(b) When the object is pulled back, the average value of the force F is 16 N and the object moves a distance 0.20 m in the direction of F. Calculate the work done. State clearly the equation that you use.

work done = ... [2]

N2000/II/2

ANSWERS

1.1 Physical quantities
1.2 SI units
1.3 Prefixes
1.5 Measurement of length and time

1. **B**	2. **E**	3. **B**	4. **B**	5. **D**
6. **D**	7. **B**	8. **B**	9. **B**	10. **C**
11. **B**	12. **B**	13. **A**	14. **A**	15. **D**
16. **B**	17. **C**	18. **A**	19. **B**	20. **D**

21. 1.53 cm
24. 23.94 mm
25. 2.52 cm
28 *(b)* 0.731 s

1.4 Scalars & vectors

1. **E**	2. **D**	3. **D**	4. **D**	5. **C**
6. **D**	7. **B**	8. **A**	9. **D**	10. **C**
11. **C**	12. **C**			

13. 6325 N at $18\frac{1}{2}°$ to 6000 N force
15. 17.2 N
16. 11.3 N
17. 12.6 km
18. 3.4 N ; 20°
19. 1460 N ; 18°
21. 259 N ; 26.6°
22. 4.0 N
23. 300 N
24. *(a)* 5200 N *(b)* 24.5°
25. 107 000 N ; 40° with F_1
27. *(b)* (i) 5 m/s (ii) 36.9°
28. *(c)* (i) 8 km (ii) 5.6 km
(iii) 2.8 km/h ; 45° east of north from **P**.
29. *(b)* (ii) 0.066 units/N
(c) (i) $\theta = 35°$
30. *(a)* 34.4 N *(b)* 3.2 J