01. 0625_s20_MS_61 Q: 3

(a)(i)	P_2 at least 5.0 cm from P_1	1
(a)(ii)	Straight line joining pin positions	1
	Extended at least 7 cm behind mirror	1
(b)(i)	Correct line and correct position of Y labelled	1
(b)(iii)	Correct *a* to within ± 2 mm	1
(b)(iii)	Correct *b* to within ± 2 mm	1
(c)(i)	Correct *x* measured and correct unit seen at *a*, *b* or *x* and not contradicted	1
(c)(ii)	Diagram to show image in mirror meeting top of pin above mirror	1
(d)	Statement to match results	1
	Justification to match statement with correct reference to results	1

(e)	Any **one** from: Thickness to mirror Thickness of lines Difficulty in judging exact lining up of pins.	1

02. 0625_s20_MS_63 Q: 3

(a)(i)	u = 4.0 (cm) and v = 8.6 (cm)	1
(a)(ii)	U = 20.0 (cm) and V = 43.0 (cm)	1
(a)(iii)	f_1 = 13.7 and unit	1
(a)(iv)	move screen backwards / slowly	1
(b)(i)	v = 3.5 (cm) and V = 17.5 (cm)	1
(b)(ii)	h_O = 2.0 (cm) and h_I = 0.8 (cm)	1
(b)(iii)	M = 0.4 and no unit	1
(b)(iv)	f_2 = 12.5 (cm)	1

(c)	any **one** from: mark position of lens on holder clamp rule / place rule on bench ensure screen, lens and object all perpendicular view scale perpendicularly	1
(d)(i)	difficult to measure height of image (accurately) as image is small	1
(d)(ii)	use larger object / graph paper on screen OR mark top and bottom of image and measure later	1

03. 0625_m19_MS_62 Q: 1

(a)(i)	θ = 23(°)±1°	1
(a)(ii)	normal correct	1
(b)	not at a suitable distance and should be far (as possible) from **N**	1
(c)	all lines present, neat and labelled correctly	1
	a = 10.2 (cm) ± 0.1 (cm)	1
(d)	**graph:** • axes labelled with quantity and unit	1
	• appropriate scales (plots occupying at least ½ grid)	1
	• plots all correct to ½ small square, precise plots	1
	• well judged line and thin continuous line	1
(e)	any suitable reason e.g.: ray has finite thickness – (difficult to mark position of ray precisely), reflecting surface of mirror at rear, inaccuracies have more effect for smaller angles, small variations in mirror angle have significant effect on 'a'	1
(f)	reflect ray below **NL** at same angles and take averages	1

04. 0625_s19_MS_62 Q: 4

	Apparatus **MP1** diagram showing object, lens, screen/image in correct order	1
	MP2 u and v correctly labelled on diagram	1
	Method **MP3** measure/record/calculate u and v and lens thickness t	1
	MP4 repeat with a different lens	1
	MP5 method of obtaining a sharp image by moving object, lens or screen….	1
	Measuring lens thickness **MP6** use of blocks either side of lens (and measure distance)	1
	Table **MP7** table with columns for u, v and t with correct units	1

05. 0625_w19_MS_62 Q: 3

(a)(i)	d = 8.0 cm or 80 mm	1
(a)(ii)	D = 80 cm or 800 mm	1
(b)	15.2 / 15.25 / 15.249 (cm)	1
(c)(i)	14.9 / 14.85 (cm)	1
(c)(ii)	correct average	1
	3 significant figures only	1
(d)	one from: darkened room / brighter lamp object and lens at same height (above bench) object and lens and screen perpendicular to the bench ruler on bench or clamped mark centre of lens (on holder) move lens slowly / back and forth (to obtain best image)	1
(e)(i)	D = 120(.0) (cm)	1
(e)(ii)	(22.2 □ 97.9) / 120 = 18.1 (cm)	1
(e)(iii)	(expect not in agreement) too far apart / not close enough / more than 10% difference between values	1

06. 0625_w19_MS_63 Q: 2

(a)(i)	u = 5.0(cm) and v = 7.6(cm)	1
(a)(ii)	U = 25(.0)(cm) and V = 38(.0)(cm)	1
(a)(iii)	f_1 15(.1)(cm) and 2/3 sig fig and unit	1
(a)(iv)	move screen slowly / backwards and forwards	1
(b)(i)	h_O = 1.5(cm) and h_I = 2.4(cm)	1
(b)(ii)	M = 1.6 and no unit	1
(b)(iii)	f_2 = 15 / 14.6(cm)	1
(c)	statement matching results	1
	values within limits of experimental accuracy / owtte	1
(d)	any **one** from: □ mark position of lens on holder ; □ clamp rule / place rule on bench ; □ ensure screen, lens and object all perpendicular (to bench) / vertical ; □ view scale perpendicularly ; □ mark top and bottom of image and measure later	1
(e)	either method suggested if matching valid explanation e.g. METHOD 1: difficult to measure height of image in method 2 METHOD 1: smaller lengths measured in method 2 / reverse argument METHOD 2: can't measure u and v to lens accurately in method 1	1

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07. 0625_s18_MS_61 Q: 3

(a)	uv values 1065, 1128, 1200, 1283, 1353	1
(b)	Graph: (all marks are still available if uv values are wrong) Axes correctly labelled and right way round	1
	Suitable scales	1
	All plots correct to ½ small square	1
	Good line judgement, thin, continuous line	1
(c)	Triangle method clearly shown on graph	1
	Triangle using at least half of candidate's line	1
(d)	G in range 14.0 to 16.0	1
	f = G to 2 or 3 significant figures	1
(e)	Any **two** from: Finding exact position that gives clearest image Measuring to centre of lens Room too bright/lamp too dim/image too faint	2

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08. 0625_s18_MS_62 Q: 3

(a)(i)	v = 5.8(0) (cm) / 58 (mm)	1
(a)(ii)	V = 29(.0) (cm)	1
(a)(iii)	f_1 = 11.8(3673) / 12 (cm)	1
(b)	f_A = 12.0 (cm)	1
	2 or 3 significant figures	1
(c)	at least 3 new values suggested	1
	all new values between 15 cm and 70 cm with at least 5 cm between each value	1
(d)	any **two** from: use of darkened room / brighter lamp mark position of centre of lens on holder place metre rule on bench / clamp in position ensure object and (centre of) lens are same height (from the bench) object and lens and screen perpendicular to bench move screen slowly / back and forth to obtain best image	2

09. 0625_s18_MS_63 Q: 3

(a)	h_O = 1.4 (cm)	1
(b)(i)	h_I = 4.5 (cm)	1
(b)(ii)	N = 0.31 / ecf	1
(c)	graph:	
	axes labelled correct orientation, with quantity and unit	1
	appropriate scales (plots occupying at least ½ grid)	1
	plots all correct to ½ small square and precise plots	1
	well judged line and thin line	1
(d)	G in range 14.0 to 17.0	1
	triangle method seen on graph occupying at least half line	1
(e)	any inherent difficulty e.g. hand / ruler in way of image **OR** screen can move (when measuring)	1
	matching improvement to apparatus e.g. use translucent screen and view from behind **OR** fix ruler / grid to screen **OR** clamp screen in place	1

10. 0625_w18_MS_61 Q: 3

(a)(i)	Normal through block and at centre of AB	1
(a)(ii)	i = 30° on correct side of normal	1
(a)(iii)	P_1 and P_2 at minimum distance apart of 5.0 cm	1
(b)(i)	Line through P_3 and P_4 straight and continued to **NL**	1
(b)(ii)	a in range 17 mm to 21 mm	1
(b)(iii)	b in range 55 mm to 56 mm and both a and b with correct unit	1
(b)(iv)	n in range 1.31–1.65, 2 or 3 significant figures	1
(c)	n = 1.5 or 1.53, both n with no unit	1
(d)	Any **two** from: Getting pins vertical / pins are bent Lining up the pins exactly / seeing pins clearly Drawing accurate / thin lines Replacing block accurately on outline / outline larger than block / owtte	2
(e)	3rd box (view bases of pins)	1

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11. 0625_w18_MS_62 Q: 3

(a)(i)	normal at centre of AB (by eye) produced to cross CD	1
(a)(ii)	i = 30° □ 1° drawn to the left of the normal	1
(a)(iii)	P_1 and P_2 in air at minimum distance apart of 5.0cm	1
(b)	line through P_3 and P_4 neat, straight and continued to N	1
(c)(i)	a = 55 □ 1 (mm)	1
(c)(ii)	b = 37 □ 1 mm and both with correct unit	1
(c)(iii)	n within the range 1.42 □ 1.60 if 3 s.f. quoted, or within the range 1.4 to 1.6 if 2 s.f. quoted	1
	2 or 3 significant figures with no unit	1
(d)	at least two additional angles suggested	1
	between 10(°) and 60(°) inclusive with at least 5(°) difference between values	1
(e)	any **one** from: large pin separation / pins at least 5 cm apart ensure that the pins are vertical / upright / perpendicular to the paper / placed straight view the bases of the pins use thin pencil lines / thin pins	1

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12. 0625_w18_MS_63 Q: 3

(a)(i)	$\alpha = 20° \pm 1°$	1
(a)(ii)	normal correct	1
(a)(iii)	pin separations $\geqslant$ 5.0 cm	1
(b)(i)	line in correct place and neat	1
(b)(ii)	$\theta = 40° \pm 1°$	1
(c)(i)	line in correct place and neat	1
(c)(ii)	$\theta = 68° \pm 1°$	1
(d)	statement matching results including qualitative justification (e.g. 'within limits of experimental accuracy' / owtte)	1
	justification that makes use of the data to support statement	1
(e)	Any **two** suitable precautions: pins upright / view pins at base; thin pins; thin lines / sharp pencil; large pin separations; ensure mirrored surface lies along drawn line.	2

13. 0625_m17_MS_62 Q: 3

(a)	h_I = 4.5 (cm)	1
(b)	correct M calculations – 3.00 / ecf, 1.50, 0.73, 0.50, 0.37	1
(c)	graph: axes labelled with quantity and unit	1
	appropriate scales (plots occupying at least ½ grid)	1
	plots all correct to within ½ small square	1
	well judged line and single, continuous thin line	1
(d)	construction line(s) clearly seen on graph	1
	u in range 28.0 to 32.0 (cm)	1
(e)	any appropriate difficulty: e.g. hand / ruler in way of image	1
	matching improvement: e.g. use translucent screen and view from behind, fix ruler / grid to screen	1
(f)	able to achieve a sharp / complete / focused image / owtte	1
	Total:	11

14. 0625_s17_MS_61 Q: 2

(a)	Normal in centre of AB and CD and FE at 30° to normal	1
	P_1 P_2 distance at least 5 cm	1
(b)	P_3 P_4 line and KE correctly drawn (to K)	1
(c)	α in range 28–32	1
	x in range 20–24 (mm)	1
(d)	Statement matches readings (Expect YES, owtte)	1
	Justification to include the idea of within (or beyond, ecf) the limits of experimental accuracy	1
(e)	Any one from: Large pin separation Ensure pins vertical / upright / erect View bases of pins Use thin pencil lines / thin pins	1
	Total:	8

15. 0625_s17_MS_62 Q: 2

(a)	normal in centre of AB at the top face	1
	FE at 40° to the left of the normal	1
	P_1 P_2 distance at least 5 cm	1
(b)	P_3 P_4 straight line and K correctly marked on CD	1
(c)	$\alpha = 40 \pm 2$	1
	$x = 17 \pm 2$ mm	1
(d)	statement is a definite YES or NO, depending on candidate's measured value of x justification to include the idea of within the limits of experimental accuracy/(very)close/almost equal etc. if YES	1
	justification to include the idea of outside the limits of experimental accuracy/too far apart/too different etc. if NO	1
(e)	any one from: large pin separation/pins must be >5 cm apart ensure pins vertical/upright/perpendicular to the paper view bases of pins use thin pencil lines/thin pins	1
	Total:	9

16. 0625_s17_MS_62 Q: 3

(a)	50 – 200 cm inclusive	1
(b)	move (the screen) slowly/carefully back and forth until the best position is found	1
(c)	9.966/9.97/10 cm	1
	answer to 2/3 significant figures (regardless of value – even if incorrect)	1
(d)	upside down/magnified/fainter/coloured	1
(e)	A, D, F	3
	Total:	8

17. 0625_s17_MS_63 Q: 3

(a)	$\theta = 30° \pm 1°$	1
(b)	distance $\geqslant 5$ cm $\leqslant 15$ cm	1
(c)(i)	normal correct	1
(c)(ii)	$a = 6.4$ (cm) and $b = 4.3$ (cm)	1
(c)(iii)	$n = 1.49$ or ecf	1
	2 or 3 sig figs and no unit	1
(d)(i)	all lines in correct places and neat	1
	$\alpha = 28° \pm 3$	1
(d)(ii)	statement matching results	1
	justification matching the statement ('within limits of experimental accuracy' / owtte)	1
(e)	difficulty in aligning pins / placing pins accurately, pins (too) thick	1
	Total:	11

18. 0625_w17_MS_61 Q: 2

(a)(i),(ii)	$v = 6.(0)$ AND $d = 8.(0)$ or $v = 60$ AND $d = 80$	1
	correct matching unit	1
(b)(i),(ii),(iii)	$V = 60$ cm (or 10 □ candidate's v) and $D = 80$ cm (or 10 □ candidate's d)	1
	UV 1200 (ecf)	1
(c)	**One** from: Different size Different brightness Sharpness / clearness / coloured edges	1
(d)(i),(ii),(iii)	f values 15(.0) and 14.9 (14.87)	1
	f_A correct method	1
	2 or 3 significant figures	1
(e)	Any **two** from: Difficulty deciding exact position of sharpest image Difficulty measuring to centre of lens Product uv increases problem Image edges blurred / not clear Insufficient sets of results	2
(f)(i)	5 – 10	1
(f)(ii)	Difference of at least 40 cm with a range 15–100	1

19. 0625_w17_MS_62 Q: 3

(a)	Graph	
	axes correctly labelled	1
	suitable scales	1
	all plots correct to ½ small square	1
	good best-fit curve judgement thin, continuous line based on all the plots	1
(b)(i)	2 points and straight line correct	1
(b)(ii)	u_1 and v_1 read correctly to ½ small square	1
(b)(iii)	correct (calculation of) *f* from candidate's values *f* value rounding to 14 – 16cm	1
(c)	any **two** from: upside down less bright / brighter coloured edges different sizes	2
(d)	any **two** from: darkened room / bright object object AND lens AND screen perp. to bench / vertical object and lens same height (from bench) move screen (**not** lens) slowly / backwards and forwards clamp rule / fix rule to bench	2

20. 0625_w17_MS_63 Q: 4

	MP1	**additional apparatus:** screen AND (metre) rule	1
	MP2	**diagram:** suitable arrangement of apparatus with *u* & *v* labelled correctly	1
	MP3	**method:** obtain (clear focused) image AND measure *u*, *v*	1
	MP4	repeat for other values of *u*	1
	MP5	**one precaution for clear, focused image:** move screen slowly / backwards and forwards, object AND lens AND screen perpendicular to bench / vertical, object and lens at same height (from bench), use of dark room / bright light	1
	MP6	**one precaution with measurements:** clamp rule / fix to bench, mark centre of lens on holder avoidance of parallax explained and specific	1
	MP7	**one additional point:** additional precaution, calculate *f* from given equation at least 3 values obtained, calculate average, mention of at least one appropriate *u* value, mention of preliminary expt to obtain rough *f* value (e.g. light from window)	1

21. 0625_m16_MS_62 Q: 3

(a) (i) normal correct [1]

(ii) $\theta = 40(°)$ [1]

(b) P_1, P_2 marked on line NM and separation > 5.0 cm [1]

(c) (i) thin lines all in correct place [1]

a = 8.1 to 8.3 (cm) and b = 5.2 to 5.5 (cm) [1]

(ii) n correctly calculated [1]

2 / 3 sig figs and no unit [1]

(d) any two suitable precautions: [2]
e.g.
- view pins from base / ensure pins upright,
- large pin separations
- use of thin pencil lines / sharp pencil / thin pins
- repeat with different angles

[Total: 9]

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22. 0625_s16_MS_61 Q: 5

(a)	u = 50, v = 21	**1**
(b)(i)	U = 500, V = 210 ecf from **(a)**	**1**
(b)(ii)	f_1 = 148 or 150 or 147.9 (mm) ecf from **(i)** 2 or 3 significant figures	**1** **1**
(c)	f_2 136 (mm) c.a.o.	**1**
(d)	Yes / statement is correct, owtte (6 mm) difference is very small / within limits of experimental error / Difference explained by uncertainty in her focal length measurement	**1** **1**
(e)	Any two from: Use of darkened room / brighter lamp Mark position of centre of lens on holder Place metre rule on bench (or clamp in position) Ensure object and (centre of) lens are same height (from the bench) Object and lens and screen perpendicular to bench Move screen (slowly) back and forth to obtain best image (owtte) Ensure rule is touching object / lens / holder / screen or look perpendicular to ruler	**2**
		Total 9

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23. 0625_s16_MS_62 Q: 3

(a)	m_1 =2.94	**1**
(b)	(m_2 = 0.329 OR 0.33) m_1 **and** m_2 to 2 or 3 significant figures only **AND** both m with no unit (accept ×)	**1**
(c)	Statement, expect YES. Must match results. e.c.f .allowed Justification to include idea of within (or beyond) limits of (experimental) accuracy	**1** **1**
(d)	Any two from: • Use of darkened room / brighter lamp / no other lights • Mark position of centre of lens on holder • Place metre rule on bench (or clamp in position) • Ensure object and centre of lens are same height from the bench • Move **lens** slowly / to and fro (when focussing) • Lens, object, screen vertical / perpendicular to bench • Repeat with different D • Use of graph paper / cm scale on screen to measure image	**max 2**

(e)	image appears well focused over a (small) range of lens positions / not all of image focussed at same time / relevant reference to chromatic aberration	**1**
		Total: 7

---

24. 0625_s16_MS_63 Q: 3

	apparatus: diagram – lens, (illuminated) object, screen in suitable order for experiment	**1**
	in line on flat surface	**1**
	instructions: set / measure object distance, move screen to get image, measure image height,	**1**
	repeat for different object distances	**1**
	limiting factor for range of object distances – one from: • image virtual / too big for screen, • image too dim / too small to measure, • must be greater than focal length	**1**
	graph: image size / magnification against object distance	**1**
	precaution: any one suitable precaution and consequence of not taking it, e.g. • dark room / bright light – image might not be distinct, • lens and object at same height – image might not appear on screen, • lens, object and screen perpendicular – image might be distorted, • fix rule – may move and give incorrect distances • mark position of lens on holder – cannot judge correct measurements / owtte • detailed means of obtaining a sharp image – might not be correctly focused • means of measuring image height accurately – might be obscured	**1**
		Total: 7

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25. 0625_w16_MS_61 Q: 3

(a)	Ray trace: $i = 20$	**1**
(b)(i)	P at least 5 cm from the block	**1**
(b)(ii)	Greater accuracy with greater distance owtte OR easier to line up accurately	**1**
(b)(iii)	19°	**1**
(c)	Graph: θ 19 (or ecf), 29,41,51,59 i 20, 30, 40, 50, 60 Axes correctly labelled and right way round Suitable scales All plots correct to ½ small square Good line judgement, thin, continuous line	 **1** **1** **1** **1**
(d)	Triangle method shown on graph and triangle using at least half of candidate's line G 0.9 – 1.1	**1** **1**
	Total:	**10**

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26. 0625_w16_MS_62 Q: 5

(a)(i)	8.4 cm / 84 mm	**1**
(a)(ii)	initial BP_2 distance at least 5.0 cm	**1**
(b)	graph: axes correctly labelled suitable scales all plots correct to ½ small square good line judgement, thin, continuous line	 **1** **1** **1** **1**
(c)	statement to match graph – expect NO justification to match statement with reference to graph line	**1** **1**
(d)	any **two** from: difficult to judge when pins are exactly in line difficult to ensure that pins are vertical/straight thickness of lines thickness of pins protractor only measures to ±1°	**2 × 1**
	Total:	**10**

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27. 0625_w16_MS_63 Q: 2

(a)(i)	$h_O = 1.5$ (cm) $h_I = 4.0$ (cm)	1 1
(a)(ii)	$M = 2.7$ (or ecf) and no unit for M	1
(a)(iii)	Answer given to 2 / 3 sig figs and with appropriate unit Value given for f_1 rounds to 14.5 or 14.6 (cm)	1 1
(a)(iv)	any appropriate difficulty: e.g. hand / ruler in way of image matching improvement: e.g. use translucent screen and view from behind use transparent ruler, fix ruler / grid to screen	1 1
(b)(i)	distance present, and $v = 25(.0)$ (cm)	1
(b)(ii)	f_2 present (expect 15.4 (cm)) and statement matching results justification matching correct statement ('within limits of experimental accuracy' / owtte)	1 1
(c)	any suitable precaution: e.g. dark room / bright light (centre of) lens and object same height (above bench), lens / object / screen perpendicular (any one will suffice), ruler fixed / placed on bench, mark centre of lens on holder repeat with different values of u / different sizes of object	1
	Total	**11**

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28. 0625_m15_MS_62 Q: 4

(a) (i) u_1 = 5.0(cm)/50(mm) [1]
v_1 = 8.7(cm)/87(mm) [1]

(ii) correct calculation of f, expect 3.1 to 3.2 (cm)/31 to 32 (mm), e.c.f.**(a)(i)** [1]
matching unit [1]

(b) u_2 in range 8.8 to 8.9(cm)/88 to 89(mm) AND statement matching results [1]
appropriate justification e.g. within limits of experimental accuracy owtte [1]

(c) two appropriate precautions, e.g. [2]

- carry out experiment in dark room/no direct (sun)light/bright lamp
- lens and object same height above bench
- lens, object and screen vertical
- move screen/lens back and forth/slowly to obtain sharp image
- fix/place rule on bench
- mark centre of lens on holder
- readings repeated

[Total: 8]

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29. 0625_s15_MS_61 Q: 4

(a) **(i)** normal at centre of AB and through block [1]

(ii) GH parallel to AB AND 6 cm ± 2 mm above AB [1]

(iii) $i = 30° \pm 2°$ to left of normal [1]

(b) P_1P_2 distance ≥ 5.0 cm [1]

(c) line KE correct, single and straight, emergent ray through P_3 and P_4 [1]

(d) a = 3.3 – 3.7 (cm); b = 6.8 – 7.2 (cm); c = 4.0 – 4.4 (cm); d = 1.4 – 1.8 (cm) [1]

n in range 1.2–1.5, no unit, 2 or 3 significant figures [1]

(e) any one from:
- large pin separation
- ensure pins are vertical
- view bases of pins
- drawing thin lines / use a sharp pencil
- use thin pins [1]

(f) ray box near start of incident ray or anywhere on incident ray; pointing in correct direction [1]

[Total: 9]

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30. 0625_s15_MS_62 Q: 4

(a) normal labelled NL [1]

(b) P_1P_2 distance > 5 cm, < 30 cm [1]

(c) **(i)** Graph:
- axes correctly labelled [1]
- suitable scales [1]
- all plots correct to ½ small square [1]
- good line judgement [1]
- thin, continuous line [1]

(ii) no [1]

line does not pass through origin [1]

(iii) difficulty in aligning pins OR pins too thick OR thickness of mirror [1]

[Total: 10]

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31. 0625_s15_MS_62 Q: 5

(a) f = 15.06(387) [1]

final answer given to 2 or 3 significant figures AND unit [1]

(b) any two from:
- darkened room / bright(er) lamp / no other lights
- moving screen slowly / back and forth to obtain best image
- mark block to show centre of lens
- place rule on bench/ clamp rule;
- lens and object same (vertical) height/level (from bench)
- lens, object and screen vertical/perpendicular to bench;
- repeat measurement/experiment (and average) [max.2]

(c) any two from:
- upside down/inverted
- size/bigger
- brightness/brighter/dimmer
- colours seen round edge/edges blurred [max.2]

[Total: 6]

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32. 0625_s15_MS_63 Q: 4

(a) **(i)** f = 3.1 [1]

(ii) F = 15.5 allow ecf [1]

(b) F_1 = 15.6 allow ecf [1]

(c) F_2 = 15.7 [1]

statement matching results [1]

appropriate justification, including idea of within limits of experimental accuracy owtte [1]

(d) appropriate precaution e.g: [1]
- carry out experiment in dark room/no direct (sun)light/bright lamp
- lens and object same height (above bench)
- lens, object and screen/mirror vertical/perpendicular
- move screen/lens back and forth/slowly to obtain sharp image
- fix/place rule on bench/clamp rule
- mark centre of lens on holder
- readings/expt repeated (and average taken)

[Total: 7]

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33. 0625_w15_MS_61 Q: 3

(a)(i)(ii) ray-trace:
- normal at 90° and crossing **MR** at intersection with P_3P_4 line [1]
- incident ray at 30° ± 2° in correct quadrant [1]
- incident ray 8.0 cm long [1]

(b) **B** to **X** at least 5.0 cm [1]

(c) **(i)** P_3P_4 line correctly drawn AND all lines single, thin, continuous lines [1]

(ii) r =31(°)–33(°) [1]

(d) any two from:
- ensure pins are vertical / view bases of pins
- pins far apart (or > 5 cm)
- ensure mirror exactly on **MR** / ensure mirror does not move
- thin lines / sharp pencil / thin pins
- repeats [2]

(e) any one from:
- thickness of lines / pencil / mirror / pins
- difficulty of lining up pins and images [1]

[Total: 9]

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34. 0625_w15_MS_61 Q: 5

(a) in correct order: object, lens, screen [1]
all three components on bench and all perpendicular to bench [1]

(b) 50–100 (cm) [1]

(c) any two from:
- difficulty in deciding exact position of lens for best image / image not quite clear owtte
- difficulty in measuring to centre of lens
- room too bright / lamp too dim [2]

(d) image shown upside down [1]

[Total: 6]

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35. 0625_w15_MS_62 Q: 4

(a)(i)(ii) ray-trace:
- normal drawn at centre of **MR** [1]
- incident ray at 30° (± 1°) [1]
- incident ray 8.0 cm long [1]

(b) P_1P_2 distance ⩾ 5 cm apart [1]

(c) (i) all lines correctly drawn AND all lines single, thin, continuous lines [1]

(ii) r = 27(°)–30(°) [1]

(d) any two from:
- ensure pins are vertical / view bases of pins
- pins far apart (or ⩾ 5 cm)
- thin lines / sharp pencil / thin pins [2]

(e) any one from:
- thickness of mirror / mirror glass silvered at back surface
- thickness of pins
- difficulty in lining up pins (and their images exactly) [1]

[Total: 9]

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36. 0625_w15_MS_63 Q: 5

(a) normal correct, through **N** [1]

(b) (i) line in correct place, **F**, labelled AND line and normal both thin, continuous and straight lines [1]

(ii)(iii) one measurement of a or b correct (a = 7.3, b = 4.1–4.2) AND unit of cm or mm [1]
both measurements correct AND unit of cm or mm [1]

(c) 1.7–1.8 AND no unit [1]

(d) any one from: [1]
- ensure pins are vertical / view bases of pins
- pins far apart (or > 5 cm)
- thin lines / sharp pencil / thin pins
- view from small angle (to normal)

(e) less reliable AND reference to smaller block depth owtte [1]
measuring smaller lengths gives greater (%) uncertainties owtte [1]

[Total: 8]

(a) angle of incidence 30° and **AB** 8.0 cm single, continuous, straight line [1]

(b) P_3P_4 line correct and neat [1]

$\alpha_o = 30 \pm 1°$ [1]

(c) **graph:**
axes correctly labelled and correct way round [1]

suitable scales, i.e. *y*-axis 2 cm = 20°, *x*-axis 2 cm = 10° [1]

all plots correct to ½ small square [1]

good line judgement [1]

single, thin, continuous line, neat points [1]

(d) triangle method seen on graph with triangle using at least half of line [1]

G between 1.9 and 2.1, ecf for axes wrong way round [1]

(e) $(\alpha - \alpha_o) = 2\theta$ or words to that effect, no ecf [1]

(f) any one from:
large(r) pin separation
view bases of pins (or ensure pins vertical)
repeat and average
thin(ner) pins
thin(ner) lines / sharp(er) pencil [max 1]

[Total: 12]

38. 0625_s14_MS_62 Q: 4

(a) (i) *x* and *y* clearly and correctly labelled to centre of lens [1]

(ii) $d = 40.9\,(\text{cm})$ no mark

(iii) $d^2 = 1673\,(\text{cm}^2)$ no mark

(iv) $f = 14.8 / 14.77$ correct answer only [1]
ignore sig. figs, but penalise incorrect rounding

cm **and** 2 or 3 sig. figs. [1]

(b) any two from:
- use of darkened room / brighter lamp / no other lights
- mark position of centre of lens on holder
- place metre rule on bench / clamp in position
- ensure object and (centre of) lens are same height (from the bench)
- repeat (and average)
- move the lens slowly / to and fro
- lens, object and screen all vertical / perpendicular to bench [max 2]

(c) (i) **two points in either order:**
one magnified, other diminished owtte [1]

one brighter than the other [1]

(ii) both inverted / both real [1]
accept same way up / same shape

(d) distance between object and screen / *D* / change position of screen [1]

[Total: 9]

39. 0625_s14_MS_63 Q: 5

(a) **(i)** $w = 2.6$ to 2.5 and $h = 2.5$ to 2.4 [1]

(ii) $s = 2.6$ or correct rounding from candidate's values [1]

(iii) appropriate reason e.g.
- w and h not always the same (NOT 'increase at different rates') (need reference to square shape – NOT just 'distorted')
- difficult to measure shadows / edges not distinct
- card might not be perpendicular / card might be tilted
- lamp is not a point source
- improve reliability [1]

(b) axes labelled with quantity and unit [1]

scales appropriate, plots covering at least ½ grid [1]

plots correct to ½ small square [1]

well judged curve [1]

thin, continuous line, precise plots [1]

(c) large gap between plots for 25 and 15 cm
allow gaps becoming larger / to ensure curve is consistent [1]
NOT 'more plots, more accurate', 'make line more accurate'

(d) any suitable reason e.g.
- shadow would be too big (for screen)
- difference between w and h becomes larger
- shadows become less distinct / more blurred / too distorted [1]

[Total: 10]

40. 0625_w14_MS_61 Q: 1

(a) normal at 90°, straight, at centre [1]

(b) incident ray at 30° on left of normal, straight [1]

(c) ray box near beginning of incident ray and pointing along it [1]

(d) reflected ray at angle of reflection approximately 30° [1]

(e) any two from:
darkened room / brighter ray box owtte
mark rays at centre / edge of beam
use sharp pencil
thin ray / small slit in ray box
perpendicular viewing of protractor [2]

[Total: 6]

41. 0625_w14_MS_61 Q: 4

(a) u = 20 mm AND v = 58 mm [1]

(b) v / u = 2.9 e.c.f. from **(a)** no unit [1]

(c) U = 200, V = 580 e.c.f. from **(a)** [1]

(d) 1.5 cm OR 15 mm [1]

(e) statement to match results (expect yes) [1]

justified by reference to results, communicating idea of within (beyond, ecf) limits of experimental accuracy [1]

(f) any two from:
use of darkened room / brighter lamp
mark position of centre of lens on holder
place metre rule on bench (or clamp in position)
ensure object and (centre of) lens are same height (from the bench)
repeats and average
moving lens / object / screen back and forth (to find sharpest image) owtte
screen and lens and object all perpendicular to bench [2]

(g) image inverted [1]

(h) any one from:
darkened room / brighter lamp
moving lens / object / screen back and forth owtte
use object with fine detail e.g. cross-wires
measure at middle of range where image is sharp [1]

[Total: 10]

42. 0625_w14_MS_62 Q: 4

(a) refracted ray in correct position and at 20°±1 [1]

(b) emergent ray in correct position and approximately parallel with incident ray [1]
note: allow a 3° tolerance

all lines present and neat [1]

(c) **(i)** P_3P_4 distance far apart, at least 5.0 cm [1]

(ii) any two from:
viewing bases of pins / ensure that pins are vertical/not bent
large pin separations
use of repeats
use of thin pencil lines (or equivalent comment)
close one eye (when aligning pins)
use thin/sharp pins [2]
ignore parallax error
NOT dark room

(d) idea of within / beyond limits of experimental accuracy [1]

[Total: 7]

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43. 0625_w14_MS_63 Q: 3

(a) h_o = 2.0 (cm) [1]

(b)(c) h_I = 1.9 (cm) [1]

S values round to 1.1 (allow ecf), 1.3, 1.7, 2(.0), 2.2, 2.5 [1]

(d) graph:
axes labelled with quantity and unit and in correct orientation [1]
appropriate scales [1]
plots correct to ½ small square [1]
well-judged straight line and thin continuous line, precise plots [1]
triangle method/information for gradient seen marked on graph [1]

(e) **(i)** *G* calculated from at least ½ line [1]

(ii) *f* in range 15 – 19 (cm) [1]

[Total: 10]

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44. 0625_s13_MS_61 Q: 4

on ray trace:
one line drawn accurately through P_3P_4 or CD [1]
both lines in correct place, neat, thin and intersecting [1]
normals Y to MR and P_1 to MR correct [1]
b = 55 – 65 (mm) [1]

(d) statement matches results (expect Yes) [1]
idea of within (or beyond) experimental accuracy [1]

(e) any one from:
large spaces between pins
make sure pins are vertical
observe bases of pins [1]

[Total: 7]

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45. 0625_s13_MS_62 Q: 5

(a) axes correctly labelled [1]
suitable scales (at least half the grid used) [1]
all plots correct to ½ small square [1]
good line judgement [1]
thin continuous line and fine plots [1]

(b) triangle method used and shown [1]
using at least half of line [1]

(c) f = 14.0 – 16.0 (cm) [1]
f to 2 or 3 significant figures with unit [1]

(d) any two from:
darkened room / brighter lamp / no other lights
(centre of) lens and object same vertical height from bench
mark block at centre of lens
clamp rule or place on bench
lens, object and screen are vertical / perpendicular to bench
repeat the measurements
move the screen backwards and forwards (to get sharpest image) [2]

[Total: 11]

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46. 0625_s13_MS_63 Q: 5

(a) u = 3.9 (cm) and d = 16.2 (cm) [1]
m = 3.15/3.2 and no unit allow e.c.f. [1]

(b) h_o = 2.0 (cm) and h_i = 6.5 (cm) [1]
M = 3.25 (2 or 3 sig. figs.) and no unit allow e.c.f. [1]

(c) statement matching results (expect 'Yes' but allow e.c.f.) [1]
justification matching statement
(expect 'within the range of experimental accuracy' o.w.t.t.e.) [1]

(d) **(i)** blurred edge / hand in way of light [1]
ensure focused properly / screen etc. vertical / attach scale/rule to screen / use translucent screen, measure at back [1]

(ii) one suitable precaution (not used in **(d)(i)**) e.g.
darkened room
mark position of lens on holder
object and lens same height
ruler fixed to bench
all apparatus vertical/right angle to bench
move screen back and forth (to obtain sharp image) [1]

[Total: 9]

47. 0625_w13_MS_61 Q: 4

(a) **(i)(ii)** u = 26 (mm) or 2.6 (cm) [1]
v = 44 (mm) or 4.4 (cm) [1]

(b) **(i)(ii)** 1144 $\underline{mm^2}$ and 70 $\underline{mm}$
OR 11.44 $\underline{cm^2}$ and 7.0 (or 7) $\underline{cm}$ [1]
e.c.f. from **(a)**

(iii) x = 16 or 16.3 or 16.34 (1.6 or 1.63 or 1.634)
e.c.f. from **(b)(i)** and **(ii)** [1]

(c) f = 16 or 16.3 or 16.34 $\underline{cm}$ (160 or 163 or 163.4 $\underline{mm}$) [1]
f given to 2 or 3 significant figures [1]

(d) up to 0.5 cm either side of 18.2 cm [1]

(e) any two from:
use of darkened room / brighter lamp / no other light interfering
mark position of centre of lens on holder
place metre rule on bench (or clamp in position)
ensure object and lens are same height from the bench
lens / object / screen perpendicular to bench
repeats
avoidance of parallax with action and reason [2]

[Total: 9]

48. 0625_w13_MS_62 Q: 4

(a) (i)(ii) u = 25(mm), v = 42(mm) [1]

(iii)(iv) uv = 1050(mm^2), $u + v$ = 67(mm) allow e.c.f. [1]

(v) f_1 = 15.7(mm) 2 or 3 significant figures only allow e.c.f. [1]

(b) (i)(ii) uv = 1050(mm^2), $u + v$ = 67(mm), c.a.o.

(iii) f_2 = 15.7(mm) accept any significant figures [1]

(c) statement matches results (expect YES) [1]
justification in terms of within or beyond limits of experimental accuracy (o.w.t.t.e.)
accept values are equal without mention of experimental accuracy [1]

(d) any two from:
use of darkened room / brighter lamp / no other lights
mark position of centre of lens on holder
place metre rule on bench (or clamp in position)
ensure object and (centre of) lens are same height (from the bench)
lens / object / screen vertical/perpendicular to bench
repeat (and average)
move lens slowly (backwards and forwards when focusing) [2]

(e) image drawn inverted [1]

[Total: 9]

49. 0625_w13_MS_63 Q: 4

(a) normal correct and pin separation at least 5 cm [1]

(b)(c) both reflected lines in correct place (through P_3, P_4 / P_5, P_6) and thin/neat [1]
$\theta = 40°$ within 1° [1]
$\theta = 62°$ within 1° [1]

(d) definite statement matching results (expect 'Yes' but allow e.c.f. if difference >10%) and justification matching statement
(expect 'within the range of experimental accuracy' or o.w.t.t.e.) [1]
values from results shown/used (correctly w.r.t statement) [1]

(e) any two suitable precautions:
thin lines / fine pencil
view protractor perpendicularly/parallax explained
lines through centre of pin holes
pins well separated
pins vertical/not bent/viewed at base
place mirror so that reflecting surface is on line o.w.t.t.e. [2]

[Total: 8]

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50. 0625_s12_MS_61 Q: 4

(a) d in range 79 to 80 (mm), 7.9 to 8.0 (cm) [1]
x = 61 (mm) and consistent correct unit for both (mm or cm) [1]
D = 80 (cm), X = 61 (cm) ecf from **(i)** and **(ii)** [1]

(b) f = 14.5(cm) allow ecf from **(a)** [1]
2 or 3 significant figures and correct unit [1]

(c) Correct statement for results (expect Yes or wtte) [1]
Idea of within (or beyond) experimental accuracy or wtte [1]
Can only score if previous mark is scored

(d) Any one from:
Use of darkened room
How to avoid parallax when taking readings
Movement of lens back and forth to obtain clearest image
Mark lens holder to show position of centre of lens
Metre rule clamped or on bench
Object, lens and screen all perpendicular to bench
Object and lens same height above bench [1]

[Total: 8]

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51. 0625_s12_MS_62 Q: 4

(a) Blocks parallel with ONE sphere completely between [1]
Rule correctly placed [1]

(b) **(i)** Line of sight perpendicular to scale [1]
Line of sight along bottom of meniscus [1]

(ii) 70 (cm^3) [1]

(iii) 0.53 cm^3, 2 or 3 significant figures, with unit [1]

[Total: 6]

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52. 0625_s12_MS_63 Q: 5

(a) Trace:
Normal at 90° in correct position [1]
N at 4 cm above AB and angle of incidence 20° [1]
a value 4.3 cm ± 1 mm correct answer only [1]

(b) All correct lines drawn, thin and continuous [1]
a and *b* both with consistent, correct unit which matches figures [1]
b value 6.2 cm ± 3 mm correct answer only [1]
n value range 1.4 – 1.5 after rounding [1]
to 2 or 3 significant figures and no unit [1]

(c) One from:
Pins well spaced
Pins at least 5 cm apart
View bases of pins
Ensure pins vertical
Use thin lines
Sharp pencil
Use thin pins [1]

[Total: 9]

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53. 0625_w12_MS_61 Q: 4

(a) Trace:
Normal at 90° in correct position [1]
Angle of incidence = 30° (± 2°) [1]

(b) P_1P_2 distance ⩾ 5.0 cm [1]
P_3P_4 line and line **GE** correctly and neatly drawn [1]

(c) **(i)** *r* = 18 or 19 or 20 [1]

(ii) *i*/*r* value correct [1]

(d) **(i)** *i*/*r* value 1.54 and both *i*/*r* values with no unit and to 2 or 3 significant figures [1]

(ii) Idea of within (or beyond) limits of experimental accuracy [1]

[Total: 8]

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54. 0625_w12_MS_62 Q: 1

Line 10 cm (± 0.1) (accept horizontal or vertical line) [1]
Normal correctly drawn [1]
Angle of incidence at 30° (± 2°) [1]
Pins at least 5 cm apart [1]

Any one from:
Thickness of lines (answer must refer to pencil lines, not light rays)
Difficulty in reading protractor to better than 2°
Thickness of pins [1]

[Total: 5]

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55. 0625_w12_MS_62 Q: 4

(a) Table: *uv* values 894, 990, 1090, 1155, 1194. Accept 3 or 4 significant figures. [1]
cm^2 and cm [1]

(b) Graph:
Axes correctly labelled and scales suitable [1]
(100 cm^2 = 2 cm on *y*-axis and 5 cm = 2 cm on *x*-axis)
All plots correct to ½ small square [1]
Good line judgement [1]
Thin, continuous line (penalise 'blobs') [1]

(c) **(i)** Triangle method used and shown [1]
Using at least half of line [1]

(ii) *f* = 14 – 16 (accept numbers rounding to 14/16) [1]
2 or 3 significant figures and unit [1]

[Total: 10]

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56. 0625_w12_MS_63 Q: 4

(a) **(i)** and **(ii)** *u* = 7.0 cm and *v* = 5.2 cm (or equivalent in mm) [1]

(iii) *u* = 0.350 and *v* = 0.260 in table (ecf) to 3 sf [1]

(b) Correct $\frac{1}{u}$ (2.86(ecf)) and $\frac{1}{v}$ (1.67, 2.55, 3.85 (ecf), 4.50, 5.10) [1]

(c) Axes labelled (including units) and appropriate scales [1]
Plots correct to ½ small square [1]
Well judged straight line [1]
Thin line and small plots [1]

(d) **(i)** and **(ii)** *p* and *q* values there and matching graph [1]

(e) **(i)** and **(ii)** f within range 0.145 to 0.155 [1]
2 or 3 significant figures and appropriate unit [1]

[Total: 10]
