

STEM SMART Phase One, 2022

Physics Week 13 – Refraction

https://isaacphysics.org/gameboards#smart_p_1_13



Essential GCSE Physics 46.3

GCSE - Practice (P3)
A Level - Practice (P1)

Data:

refractive index of glass = 1.50

refractive index of air = 1.00

speed of light in a vacuum = 3.00×10^8 m/s

Calculate r for light entering glass from air if:

Part A $i = 20^\circ$

$i = 20^\circ$

Part B $i = 30^\circ$

$i = 30^\circ$

Part C $i = 40^\circ$

$i = 40^\circ$



Essential GCSE Physics 46.4

GCSE - Practice (P3)
A Level - Practice (P1)

Data:

refractive index of glass = 1.50

refractive index of air = 1.00

speed of light in a vacuum = 3.00×10^8 m/s

Calculate r for light leaving glass into air if:

Part A $i = 20^\circ$

$i = 20^\circ$

Part B $i = 30^\circ$

$i = 30^\circ$

Part C $i = 40^\circ$

$i = 40^\circ$



Essential GCSE Physics 47.3

GCSE - Practice (P3)
A Level - Practice (P1)

The critical angle for light leaving diamond into air is 24° .

Calculate the refractive index (n) for diamond.



Essential GCSE Physics 47.8

GCSE - Practice (P3)
A Level - Practice (P1)

A tube of glass of refractive index 1.65 is surrounded by glass of refractive index 1.51.

Calculate the critical angle for light travelling along the tube and incident on the boundary between the glasses.



Mirage

GCSE - Challenge (C3)
A Level - Challenge (C1)

A thin layer of calm air immediately above a hot, flat desert is at the same temperature as the desert ground beneath it. Above this layer the temperature of the air abruptly changes to a uniform cooler value. A person with eyes $h = 2.00$ m above the ground has the impression that they are standing at the centre of a circular 'island' of sand, surrounded by a mirror-like surface, reminiscent of water.

Part A Refractive index of warm air

Calculate the refractive index for the warm air if the horizontal distance from the person to the rim of this 'island' is $L = 20.2$ m and the refractive index of the cooler air is 1.05 .

Part B Apparent radius

As the day progresses, the bottom layer of air heats up even more, changing the refractive index to 1.02 , what is the new radius of the man's 'island'?

Adapted with permission from UCLES, A Level Physics, June 1967, Paper 2, Question 2

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Optical Dipstick

GCSE - Challenge (C3)
A Level - Challenge (C1)

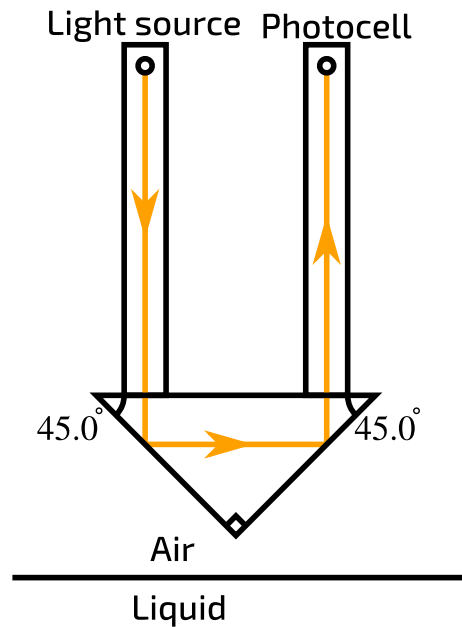


Figure 1: Optical dipstick

The figure shows an optical 'dip-stick' for automatic control of the depth of the liquids in tanks.

Part A Refractive index

If the search prism (drawn above) is in air, above the liquid surface, the light from the lamp is returned to the photocell with little loss as long as the refractive index of the prism exceeds a certain value n . Calculate n . Give your answer to 3 significant figures.

Part B Use as a dipstick

The refractive index of the prism is now $n_1 = 1.90$ and the prism is immersed in a liquid. The liquid is a solution where the concentration changes with depth so that the refractive index varies linearly with depth. The refractive index is 1.33 at the surface and 1.39 at a depth of 12.0 cm. At what depth will the light no longer completely reach the photocell? Give your answer to 3 significant figures.

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Essential Pre-Uni Physics D8.1

GCSE - Challenge (C3)
A Level - Practice (P1)

Physical constants which may be necessary to answer the problems on this page can be found within the hint tabs.

Refractive index of crown glass: 1.51

Refractive index of flint glass: 1.61

Refractive index of water: 1.34

Refractive index of cubic zirconia: 2.16

Refractive index of diamond: 2.42

Take the refractive index of air to be 1.00.

Complete the table to show the missing angles. In some cases, refraction is impossible. **In these cases give your answer as "99" with unit "none".**

Consider all angles to have been given to 2 significant figures.

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Air	30	Crown Glass	(a)
Air	30	Flint Glass	(b)
Air	13	Flint Glass	(c)
Air	(d)	Crown Glass	30

Part A Air to crown glass

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Air	30	Crown Glass	(a)

a) What is the angle of refraction in degrees?

Part B Air to flint glass

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Air	30	Flint Glass	(b)

b) What is the angle of refraction in degrees?

Part C Air to flint glass

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Air	13	Flint Glass	(c)

c) What is the angle of refraction in degrees?

Part D Air to crown glass

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Air	(d)	Crown Glass	30

d) What is the angle of incidence in degrees?



Essential Pre-Uni Physics D8.2

GCSE - Challenge (C3)
A Level - Practice (P1)

Physical constants which may be necessary to answer the problems on this page can be found within the hint tabs.

Refractive index of crown glass: 1.51

Refractive index of flint glass: 1.61

Refractive index of water: 1.34

Refractive index of cubic zirconia: 2.16

Refractive index of diamond: 2.42

Take the refractive index of air to be 1.00.

Complete the table to show the missing angles. In some cases, refraction is impossible. **In these cases give your answer as "99" with the unit "none".**

Consider all angles to have been given to 2 significant figures.

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Crown Glass	50	Air	(a)
Crown Glass	40	Water	(b)
Crown Glass	50	Flint Glass	(c)

Part A Crown glass to air

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Crown Glass	50	Air	(a)

a) What is the angle of refraction in degrees?

Part B Crown glass to water

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Crown Glass	40	Water	(b)

b) What is the angle of refraction in degrees?

Part C Crown glass to flint glass

Light passing fromto	
Material	Angle of Incidence / °	Material	Angle of Refraction / °
Crown Glass	50	Flint Glass	(c)

c) What is the angle of refraction in degrees?



Essential Pre-Uni Physics D8.4

GCSE - Challenge (C3)
A Level - Practice (P1)

Physical constants which may be necessary to answer the problems on this page can be found within the hint tabs.

Refractive index of crown glass: 1.51

Refractive index of flint glass: 1.61

Refractive index of water: 1.34

Refractive index of cubic zirconia: 2.16

Refractive index of diamond: 2.42

Take the refractive index of air to be 1.00.

Complete the table to show the missing critical angles.

Boundary between		Critical Angle / °
Water	Air	(a)
Crown Glass	Air	(b)
Flint Glass	Air	(c)
Cubic Zirconia	Air	(d)
Diamond	Air	(e)

Part A Water and air

Boundary between		Critical Angle / °
Water	Air	(a)

a) What's the critical angle in degrees?

Part B Crown glass and air

Boundary between		Critical Angle / °
Crown Glass	Air	(b)

b) What's the critical angle in degrees?

Part C Flint glass and air

Boundary between		Critical Angle / °
Flint Glass	Air	(c)

c) What's the critical angle in degrees?

Part D Cubic zirconia and air

Boundary between		Critical Angle / °
Cubic Zirconia	Air	(d)

d) What's the critical angle in degrees?

Part E Diamond and air

Boundary between		Critical Angle / °
Diamond	Air	(e)

e) What's the critical angle in degrees?



Essential Pre-Uni Physics D8.6

GCSE - Challenge (C3)
A Level - Practice (P1)

Physical constants which may be necessary to answer the problems on this page can be found within the hint tabs.

Refractive index of crown glass: 1.51

Refractive index of flint glass: 1.61

Refractive index of water: 1.34

Refractive index of cubic zirconia: 2.16

Refractive index of diamond: 2.42

Take the refractive index of air to be 1.00.

Part A Flint glass

Calculate the speed of light in flint glass.

Part B Diamond

Calculate the speed of light in diamond.
