



Useful information for attending our Sonar courses

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Location

Both courses will be held in the Inspire Lecture Theatre in our Fusion Building, which is located on our Talbot Campus. A map to the campus is available on page 3 and a campus map can be found on page 4.

Car Parking

We are unfortunately no longer able to offer free parking for our visitors or event attendees. Limited paid parking is available at our Visitor & Events Car Park, indicated on the campus map on page 4. This parking can be paid for at the ticket machine in the car park, or in advance via <https://pay.hozah.com/locations/1167>

Bus Service

Buses for BU are operated by More, the bus service that serves the University, during the vacation this is restricted to a shuttle service (Route U1) between the location of one of the largest halls of residence and Talbot Campus (where the Sonar Course takes place) as well as other services www.morebus.co.uk Yellow buses also operate services that call at the University full details of routes and timetables can be found at www.bybus.co.uk

Lunch and Refreshments

Lunch is included in the course fee and will be via vouchers provided to you on your arrival. These vouchers can be redeemed in The Fusion Building restaurant. Tea, coffee, water, Danish pastries or biscuits and fruit will be provided in the morning, with tea/coffee/water and biscuits available in the afternoon.

Course Notes

A set of course notes will be provided as per the option that was chosen when you were registered on the course (physical copy, digital copy on a USB flash drive, or digital copy by email).

Certificate of Completion

Following the course, you will be provided with a certificate confirming your completion of the course.

COVID-19

If you have symptoms prior to attending these courses please take a Lateral Flow test to ensure you don't expose other attendees to COVID. If you develop symptoms during the course you must let us know as soon as possible and are required to follow NHS guidance to self-isolate.

We look forward to welcoming you to Bournemouth University and wish you a pleasant journey.

Faculty of Media, Science & Technology
Bournemouth University,
Poole House, Talbot Campus, Poole, Dorset BH12 5BB
sonar@bournemouth.ac.uk

Accommodation

If accommodation is required, this can be booked by contacting any of the below suggestions. It should also be noted that Bournemouth and Poole have a large number of hotels if the below do not meet your requirements.

- The **Bournemouth Highcliff** Marriot Hotel is on the clifftops at Bournemouth. Find out more at their website www.BournemouthHighcliffMarriott.co.uk.
- The **Oceana Group** of Hotels which include **The Cumberland, Ocean Beach, Royale, Suncliffe** and **Mayfair** are all about 15 minutes' drive from the University, and not far from the seafront. They can be contacted on 01202 298350 or email Central Reservations at cr@oceanahotels.co.uk. More information is on their website <https://www.oceana-collection.com/>
- The **Miramar Hotel** is similarly located and can be contacted on 01202 410156, and on their website www.miramar-bournemouth.com.
- The **Green House Hotel** is also in this area and can be contacted on 01202 498900 or via the website www.thegreenhousehotel.co.uk
- Finally, **the Village Hotel** is located on the outskirts of Bournemouth just off the A338. It can be contacted on 01202 055205 and more information is on the website www.village-hotels.co.uk

Alternatively, you can access online accommodation lists and bookings by visiting the below websites:

- www.bournemouth.co.uk and follow the links to Accommodation
- <http://www.pooletourism.com/> and follow the links to Book Accommodation online

Please note that delegates are responsible for arranging and paying for their own travel and overnight accommodation. There are a large number of taxis operating in the town, and these can be booked by your hotel. In addition, there is also a shuttle bus that operates between the Lansdowne (where a number of hotels are) and Talbot Campus where the course is being held.

How to find us



To reach **Lansdowne Campus** from the north or east, leave the A338 at the junction marked Travel Interchange onto St Paul's Road, then take St Swithuns Road. At the roundabout at the end of St Swithuns Road, take the right-hand exit which will bring you onto Christchurch Road (B3066) where the buildings that comprise the campus are located.

From the west, follow the directions to Talbot Campus but proceed past the university on the A3049 (this becomes Talbot Avenue). Next take Wimborne Road (A347), then Lansdowne Road (B3064) to continue onto Christchurch Road (B3066).

Postcode for Sat Nav: BH8 8EB

Talbot Campus can be reached from the north or east via the A338 (locally known as the Wessex Way). Take the exit at the Richmond Hill Roundabout (next to the Vitality Insurance tower) and then follow the signs for the university.

From the west on the A35 follow the signs to Bournemouth (A3049), taking the dual-carriageway (Dorset Way) past Tower Park. Talbot Campus is located on the A3049 (Wallisdown Road).

Talbot Campus has a limited number of pay and display visitor parking bays. Student and staff parking is for permit holders only.

Postcode for Sat Nav: BH12 5BB

Talbot Campus Map



Amenities Key

- Disabled toilets
- Ramp
- Cafe/Restaurant
- Fire muster point
- Students' Union shop
- Main reception
- SportBU reception
- Bank/cash point
- Medical centre
- Waste area
- Defibrillator
- Baby change
- Changing places facility
- Cyclist shower facilities
- Faith & Reflection
- Nursery
- Coin/phonecard phone
- Photobooth
- Permit holders car parks (Monday-Friday, 7am-4pm)
- Blue badge car parking
- Pedestrian access
- Bicycle access
- Pedestrian path
- Lift share parking
- Bicycle parking (covered)
- Bicycle parking (uncovered)
- Beryl Bike parking
- Motorbike parking
- 20 minute drop off zone
- Electric vehicle charging
- Vehicle drop off/collection
- Bus hub
- Coach drop off/collection

Locations Key

- 1 Design & Engineering Innovation Centre
- 2 Estates Office
- 3 Shelley Lecture Theatre
- 4 IT Help Zone
- 5 Open Access Centre
- 6 24 hour computer room
- 7 AskBU at The Base
- 8 Centre for Fusion Learning Innovation & Excellence
- 9 Global Mobility Hub
- 10 Atrium Gallery
- 11 Staff Centre
- 12 Dylan's Bar
- 13 Human Performance Laboratories
- 14 Loading Bay
- 15 Lees Lecture Theatre
- 16 Lawrence Lecture Theatre
- 17 Stevenson Lecture Theatre
- 18 Cobham Lecture Theatre
- 19 Barnes Lecture Theatre
- 20 KG03 Lecture Theatre
- 21 Marconi Lecture Theatre
- 22 KG01 Lecture Theatre
- 23 Students' Union (SUBU)
- 24 Biome
- 25 Doctoral College
- 26 The Purbeck Room
- 27 Allsebrook Lecture Theatre
- 28 Careers Centre
- 29 Create Lecture Theatre
- 30 Share Lecture Theatre
- 31 Inspire Lecture Theatre
- 32 Peach Tree Room - Student Lounge
- 33 Crime Scene training facility
- 34 Student Hall

PROVISIONAL TIMETABLE

Monday		Introduction to Sonar Day 1 – Fusion Building, Inspire LT	Tutor	Notes section
09:00 - 09:15	<i>Arrival – Fusion Building (Inspire LT)</i>		Prof Philip Sewell	
09:15 – 09:30	Welcome & Introduction		BU Dr Graham Alker	
09:30 – 10:00	Basics of Sonar		Dr Graham Alker	11
	<i>Coffee</i>			
10:15 – 12:30	Acoustic Wave Motion		Dr Graham Alker	12
	<i>LUNCH</i>			
13:30 – 14:30	Acoustic Propagation & Sonar Equation		Dr Graham Alker	13
	<i>Coffee</i>			
14:45 – 15:15	dB Exercises		Dr Graham Alker	
15:15 – 16:30	Sonar - Transducers & Beamforming		Dr Graham Alker	14
Tuesday		Day 2 - Fusion Building, Inspire LT		
09:00 – 10:30	Noise & Reverberation		Dr Jim Parberry	15
	<i>Coffee</i>			
10:45 – 12:00	Signal Processing & Displays		Dr Jim Parberry	16
12:00 – 12:30	Arrays		Dr Jim Parberry	17
	<i>LUNCH</i>			
13:00 – 15:15	Experimental Demonstrations (PG141)/Software Demonstration (Inspire LT)		Dr Diogo Montalvao/ Dr Jim Parberry/ Russell Wade	18
	<i>Coffee</i>			
15:30 – 16:30	Sonar Systems Reviewed and Tutorial Questions		Dr Jim Parberry	19



FUNDAMENTALS OF SONAR
to be held at
BOURNEMOUTH UNIVERSITY
 9th September – 11th September 2026

PROVISIONAL TIMETABLE

Wednesday		Fundamentals of Sonar Day 1 – Fusion Building, Inspire LT		Tutor	Notes section
09:00 - 09:15	<i>Arrival – Fusion Building (Inspire LT)</i>			Prof Philip Sewell	
09:15 – 10:15	Acoustic Wave Theory			Dr Graham Alker	F1
	<i>Coffee</i>				
10:30 – 11:30	Acoustic Wave Theory - continued			Dr G Graham Alker	F1
11:30 – 12:30	Fourier Methods			Dr G Graham Alker	F2
	<i>LUNCH</i>				
13:30 – 14:45	Transducer Technology			Thales	F3
	<i>Coffee</i>				
15:00 – 15:30	Transducer Technology - continued			Thales	F3
15:30 – 17:15	Sonar Imaging Systems			University of Bath	F4

Thursday		Day 2 - Kimmeridge House, KG03			
09.00 – 10:00	Radiated Noise			QinetiQ	F5
	<i>Coffee</i>				
10.15 – 12:00	Target Echo Strength			Dstl	F6
12:00 – 13:00	Signal Processing and Displays			Kaon Ltd	F7
	<i>LUNCH</i>				
13.30 – 15:00	Data Processing			Kaon Ltd	F8
15:00 – 15:15	<i>Coffee</i>				
15:15 – 17:00	Towed Arrays			TKMS ATLAS UK	F9

Friday		Day 3 - Fusion Building, Inspire LT			
09.00 – 10.30	Propagation			Marcus Donnelly	F10
	<i>Coffee</i>				
10.45 – 11:45	The Sonar Equation			Marcus Donnelly	F11
11:45 – 13:15	Sonar Equation Calculations & Tutorial			Marcus Donnelly	F11
	<i>LUNCH</i>				

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Optional Algebra Revision

Dr Graham Alker, who delivers some of the lectures on the sonar course has asked that we include this for all delegates so that they can brush up on some of the relevant principles of algebra as they relate to sonar if they choose to. The feedback that we have received from previous courses indicates that many find this useful.

Algebra revision for Introduction to Sonar

This is intended to give a simple reminder and the opportunity to practise some useful techniques for those whose mathematics is rusty. It is not a rigorous mathematical introduction. The correct answers to all **practice** questions are within [] and long decimal answers are truncated. It is recommended *but not necessary* that the practice questions are attempted.

Decibels (dB) are used extensively in acoustics and use the function $\log_{10}(x)$. Practice examples are given using $\log_{10}(x)$ and 10^x .

Functions

A function is a rule which maps a set of numbers to another set of numbers. It is simple: give the function a number and it responds with a number. Example $f(x) = 2x^2 + 3$ note x is called the 'argument', Giving the function the number 2, or equivalently setting $x = 2$, $f(x) = 11$

The usual method of evaluation for $f = 2x^2 + 3$ when $x=7$ is:

$$\begin{aligned} f &= 2 \times x^2 + 3 \\ f &= 2 \times 7^2 + 3 \\ f &= 2 \times 49 + 3 \\ f &= 98 + 3 \\ f &= 101 \end{aligned}$$

Practice:

Evaluate $f(x) = 10x - 7$	for $x = 2$	[13]
	for $x = 3.7$	[30]
	for $x = -1$	[-17]
Evaluate $f(x) = 3x^2 + 4$	for $x = 2$	[16]
	for $x = 3.7$	[45.07]
	for $x = -1$	[7]

Inverse functions

Given a function $f(x)$ and a value of the function, what was the value of x which led to this? This is the inverse function often denoted as $f^{-1}(x)$

Example $f = 2x + 3$ if $f = 5$, what was x ? The answer is $x = 1$

The method of finding x for $f = 2x^2 + 3$ when $f=21$ is:

$$\begin{aligned} 2x^2 + 3 &= 21 \\ 2x^2 &= 18 \\ x^2 &= 9 \\ x &= \sqrt{9} \\ x &= \pm 3 \end{aligned}$$

Practice:

$f(x) = 10x - 7$	find x	when $f = 3$	[1]
		when $f = 8$	[1.5]
$f(x) = 3x^2 + 4$	find x	when $f = 31$	[±3]
		when $f = 8$	[±1.1547...]
		when $f = 2$	[no real solution]

Powers and logarithms

Raising a number or a variable to a power indicates the number of times it should be multiplied by itself. The notation is x^n which is interpreted as x multiplied by itself 'n' times. 'n' is referred to as the exponent. This was introduced as a shorthand and initially was only defined for positive integers 1,2,3 ... The first three powers of the number 10 are thus:

$$10^1 = 10 \quad 10^2 = 10 \times 10 = 100 \quad 10^3 = 10 \times 10 \times 10 = 1000 \quad \dots$$

Multiplying turns out to be easy: to multiply 10^2 by 10^3 , the safe way is to write them out as ordinary numbers, multiply and rewrite in the exponent notation:

$$10^2 \times 10^3 = 10 \times 10 \times 10 \times 10 \times 10 = 10^5$$

In general, for two exponents m and n

$$10^m \times 10^n = 10^{m+n}$$

Dividing is similar: divide 10^3 by 10^2

$$10^3 / 10^2 = 10 \times 10 \times 10 / (10 \times 10) = 10 = 10^1$$

In general, for two exponents m and n

$$10^m / 10^n = 10^{m-n}$$

There are potential problems here, if $m=n$ then the answer would be 10^0 , what does this mean? Of course, we know the answer: $10^2 / 10^2 = 1$ so we define $10^0 = 1$ and the definition of powers is extended to 0,1,2,3 ...

If $m < n$, for example: $10^2 / 10^3 = 10^{-1}$ the exponent is negative, what does this mean?

We know that $100/1000$ is $1/10$, so it appears that 10^{-m} simply means $1/10^m$. Check: $100/10000 = 1/100$ by powers:

$$10^2 / 10^4 = 10^{-2} = 1/10^2$$

So, we define $10^{-m} = 1/10^m$. The definition of powers is now extended to both positive and negative numbers and zero.

Next consider $(10^3)^4 = (10^3) \times (10^3) \times (10^3) \times (10^3) = 10^{12}$

so $(10^n)^m = 10^{nm}$

The rules for manipulating powers are:

$$10^m \times 10^n = 10^{m+n}, \quad (10^n)^m = 10^{nm}, \quad 10^m / 10^n = 10^{m-n}, \quad 10^0 = 1, \quad 10^{-m} = 1/10^m$$

10 has been used as an example. In general, for any numbers $x, m, n, x \neq 0$

$$x^m \times x^n = x^{m+n}, \quad (x^n)^m = x^{nm}, \quad x^m / x^n = x^{m-n}, \quad x^0 = 1, \quad x^{-m} = 1/x^m$$

Fractional powers

Multiplying a number by itself a half a number of times does not sound sensible. However, a sensible value of $10^{0.5}$ can be found. If this number is multiplied by itself applying the rule above:

$$10^{0.5} \times 10^{0.5} = 10^1 = 10$$

$$\text{hence } 10^{0.5} = \sqrt{10}$$

This can be extended, for example $10^{0.7}$ can be interpreted as the tenth root of 10 multiplied by itself 7 times ie $(10^{0.1})^7$. In this way an understanding of 10^x can be defined for all real values of x.

Practice using a calculator:

$$\text{Evaluate } 10^5 \quad [100000]$$

$$\text{Evaluate } 10^2 \quad [100]$$

$$\text{Evaluate } 10^{-3} \quad [0.001]$$

$$\text{Evaluate } 10^{1.376} \quad [23.7684]$$

$\log(x)$ (formally $\log_{10}(x)$) is the inverse function of 10^x

$$10^3 = 1000 \quad \log(1000) = 3$$

$$10^{2.5} = 316.2278 \quad \log(316.2278) = 2.5$$

$$\log(1) = 0$$

$$\log(xy) = \log(x) + \log(y)$$

$$\log(x/y) = \log(x) - \log(y)$$

$$\log(1/y) = -\log(y)$$

Practice:

$$\text{Evaluate } 10^4 \quad [10000]$$

$$\text{Evaluate } \log_{10}(10000) \quad [4]$$

$$\text{Evaluate } \log_{10}(38.4) \quad [1.58433]$$

$$\text{Evaluate } 10^{1.58433} \quad [38.4]$$

$$\text{Question} \quad \text{If } \log_{10}(x) = 1.8 \text{ what is } x? \quad \text{Answer} \quad x = 10^{1.8} = 63.096$$

Practice:

$$\text{If } \log_{10}(x) = 0.8 \text{ what is } x? \quad [6.3096]$$

$$\text{If } \log_{10}(x) = -1.4 \text{ what is } x? \quad [0.0398]$$

$$\text{If } \log_{10}(x) = 4.4 \text{ what is } x? \quad [25188.9]$$

$$\text{Question} \quad \text{If } 10\log_{10}(x) = 23 \text{ what is } x?$$

$$\log_{10}(x) = 23/10 = 2.3$$

$$x = 10^{2.3}$$

$$x = 199.5$$

Practice:

If $10 \log_{10}(x) = 60$ what is x ? [1000000 = 10^6]

If $10 \log_{10}(x) = 64$ what is x ? [2511886]

If $20 \log_{10}(x) = 64$ what is x ? [1584.9]

If $20 \log_{10}(x) = 49$ what is x ? [281.8]

Practice:

Evaluate $\log_{10}(10)$ [1]

Evaluate $\log_{10}(1000)$ [3]

Evaluate $\log_{10}(0.001)$ [-3]

Evaluate $\log_{10}(2)$ [0.3]

Evaluate $\log_{10}(3)$ [0.48]

Evaluate $\log_{10}(6)$ [0.78]

So $\log_{10}(2) + \log_{10}(3) = \log_{10}(6)$

Evaluate $\log_{10}(4)$ [0.6]

Evaluate $\log_{10}(40)$ [1.6]

Evaluate $\log_{10}(0.4)$ [-0.4]

Learn the following:

$$\log_{10}(10) = 1$$

$$\log_{10}(10^n) = n$$

$$\log_{10}(2) = 0.3$$

Algebra revision for Fundamentals of Sonar

Complex Numbers

A complex number z may be written

$$z = x + iy$$

Here the real part is x and imaginary part is y and i is $\sqrt{-1}$

Addition of complex numbers is as expected, if $d = a + ib$ then

$$z + d = x + a + i(y + b)$$

Multiplication uses the relation $i^2 = -1$

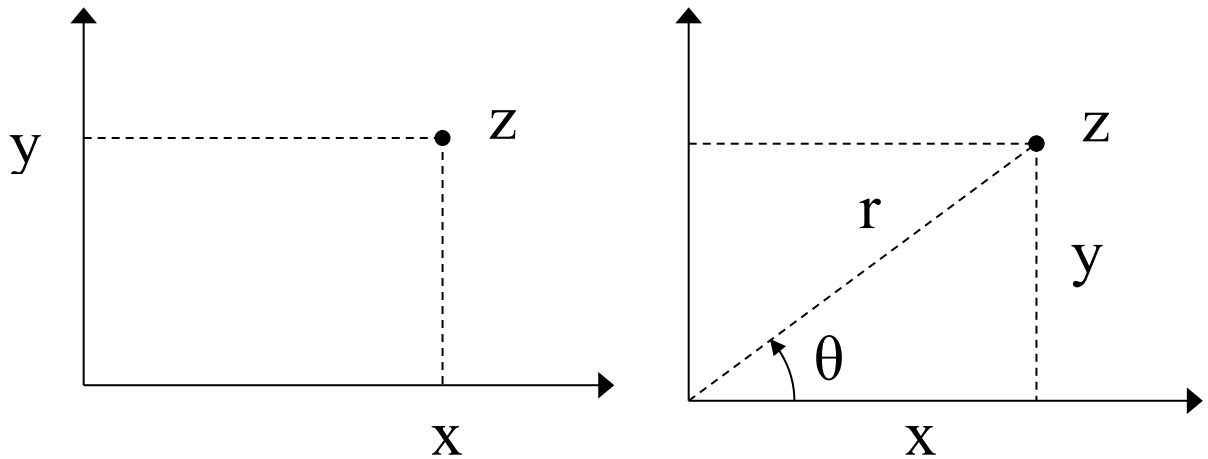
$$zd = (x + iy)(a + ib) = xa - yb + i(xb + ya)$$

Practice:

If $z = 2 + 3i$, $d = 2 + i$, and $w = 2 - 3i$,

Evaluate	$z + d$	$[4+4i]$
Evaluate	zd	$[1+8i]$
Evaluate	$z + w$	$[4]$
Evaluate	zw	$[13]$

Complex numbers may be represented in a 2-D plane:



Then $x = r \cos \theta, y = r \sin \theta, r = \sqrt{x^2 + y^2}$

Recall $e^{i\theta} = \cos \theta + i \sin \theta, \theta \text{ radians}$

Therefore $z = r(\cos \theta + i \sin \theta) = re^{i\theta}$

The real part of a complex number z is written as

$\Re(z) = x = r \cos \theta$

It is useful to write a complex number in the form $re^{i\theta}$

Example

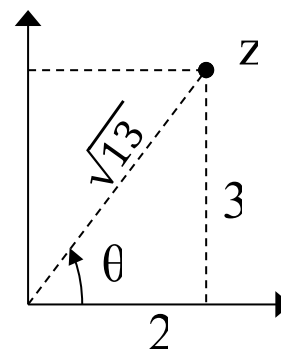
Write $z = 2+3i$ in the form $re^{i\theta}$

$r = \sqrt{13} \quad \theta = \cos^{-1}(2/\sqrt{13})$

$z = \sqrt{13} e^{i \cos^{-1}(2/\sqrt{13})}$

$z = 3.6056e^{0.9828i}$

similarly, $w = 3.6056e^{-0.9828i}$



Note w is the complex conjugate of z , the real parts are the same, the imaginary parts have opposite signs

Practice

Write z in the form $re^{i\theta}$

z	$re^{i\theta}$
2	$[2]$
-3	$[3e^{i\pi}]$
4i	$[4e^{i\pi/2}]$
1+i	$[\sqrt{2} e^{i\pi/4}]$
-6i	$[6e^{-i\pi/2}]$