London Mathematical Society EPSRC Durham Symposium

Permutation groups and transformation semigroups

Monday 20th July - Thursday 30th July 2015

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Schedule of Talks

Note: All talks will take place in CG93 (through the Maths department main entrance, straight on downstairs, along the corridor).
Lunches and dinners are at Grey College.

Jul 20 (Mon)

14:00 - 19:00 Registration at Grey College

19:00 - 20:00 Dinner at Grey College

Jul 21 (Tue)

08:00 - 09:00 Breakfast

09:00 - 10:00 Benjamin Steinberg: *The representation theory of finite monoids (Part I)*

10:00 - 10:30 Coffee

10:30 - 11:30 Rehana Patel: *Ergodic invariant measures as probabilistic structures (Nathanael Ackerman, Cameron Freer, Rehana Patel)*

11:40 - 12:10 Peter Higgins: *Using transformations to embed finite semigroups of a certain type in 2-generated finite semigroups of the same type.*

12:10 - 12:40 Chrystopher Nehaniv: *Coproducts for Permutation Groups, Transformation Semigroups, Automata and Related Categories*

13:00 - 14:00 Lunch at Grey College

14:30 - 15:00 James East: *Linear sandwich semigroups*

15:00 - 15:30 Michael Kinyon: *Automorphic loops and their associated permutation groups*

15:30 - 16:00 Coffee

16:00 - 17:00 Christian Rosendal: *Large scale geometry of automorphism groups (Part I)*

17:10 - 18:10 J Truss: *Definability properties of the monoid of endomorphisms of the rational numbers*

18:15 - 19:30 Welcome drinks

19:30 - 20:30 Dinner at Grey College

Jul 22 (Wed)

08:00 - 09:00 Breakfast

09:00 - 10:00 Christian Rosendal: *Large scale geometry of automorphism groups (Part II)*

10:00 - 10:30 Coffee

10:30 - 11:30 Mark Kambites: *Amenability and geometry of semigroups*

11:40 - 12:10 Gregory Cherlin: *Metrically Homogeneous Graphs of Generic Type*

12:10 - 12:40 Problem Session 1

13:00 - 14:00 Lunch at Grey College

15:30 - 16:00 Coffee

16:00 - 17:00 Benjamin Steinberg: *The representation theory of finite monoids (Part II)*

17:10 - 18:10 M Droste: *The normal subsemigroups of the monoid of injective maps*

19:00 - 20:00 Dinner

Jul 23 (Thu)

08:00 - 09:00 Breakfast

09:00 - 10:00 Benjamin Steinberg: *The representation theory of finite monoids (Part III)*

10:00 - 10:30 Coffee

10:30 - 11:30 Cameron Freer: *Ergodic invariant measures as probabilistic structures*

11:40 - 12:10 Attila Egri-Nagy: *Finite Diagram Semigroups: Extending the Computational Horizon*

12:10 - 12:40 Christian Pech: *Reconstructing the topology of polymorphism clones*

13:00 - 14:00 Lunch at Grey College

14:30 - 15:30 Mikhail Volkov: *Representations of finite J-trivial monoids and finite block-groups by transformations and relations*

15:30 - 16:00 Coffee

16:00 - 17:00 Christian Rosendal: *Large scale geometry of automorphism groups (Part III)*

17:10 - 18:10 Todor Tsankov: *Banach representations of dynamical systems and model theory*

19:00 - 20:00 Dinner

Jul 24 (Fri)

08:00 - 09:00 Breakfast

09:00 - 10:00 Jan Hubicka: *Ramsey Classes by Partite Construction (Part I)*

10:00 - 10:30 Coffee

10:30 - 11:30 Slawomir Solecki: *Homogeneity of the pseudo-arc through permutation groups*

11:40 - 12:10 Will Anscombe: *Generalised measures on free homogeneous structures*

12:10 - 12:40 Artur Schaefer: *Synchronization Theory and Links to Combinatorics*

13:00 - 14:00 Lunch at Grey College

14:00 - 14:30 Conference photograph

14:30 - 17:00 Cathedral Tour and Magna Carta

19:00 - 20:00 Dinner

Jul 25 (Sat)

08:00 - 09:00 Breakfast

09:00 - 10:00 Jan Hubicka: *Ramsey Classes by Partite Construction (Part II)*

10:00 - 10:30 Coffee

10:30 - 11:30 Nate Ackerman: *Ergodic invariant measures as probabilistic structures*

11:40 - 12:10 Nicholas Loughlin: *The Brauer Project*

12:10 - 12:40 Edith Vargas-Garcia: *Introduction to the reconstruction for the topological monoid of the rationals.*

13:00 - 14:00 Lunch at Grey College

14:30 - 15:30 Mikhail Volkov: *Cerny's type problem for transformation semigroups*

15:30 - 16:00 Coffee

16:00 - 17:00 Igor Dolinka: *Representing semigroups and groups by endomorphisms of Fraïssé limits (Part I)*

17:10 - 18:10 Simon Thomas: *Invariant random subgroups of locally finite groups*

19:00 - 20:00 Dinner

Jul 26 (Sun)

08:00 - 09:00 Breakfast

09:00 - 18:00 Day trip to Whitby and Robin Hood Bay

19:00 - 20:00 Dinner

Jul 27 (Mon)

08:00 - 09:00 Breakfast

09:00 - 10:00 Wolfram Bentz: *How synchronizing are primitive groups?*

10:00 - 10:30 Coffee

10:30 - 11:30 Gordon Royle: *Endomorphisms and Synchronisation*

11:40 - 12:10 James Hyde: *2-Generation In Groups Of Homeomorphisms Of The Cantor Set*

12:10 - 12:40 Problem Session 2

13:00 - 14:00 Lunch at Grey College

14:30 - 15:30 Katrin Tent: *Sharply 3-transitive groups*

15:30 - 16:00 Coffee

16:00 - 17:00 Michael Pinsker: *Topological clones (Part I)*

17:10 - 18:10 J Araujo: *Groups and semigroups: from a duet to a chorus*

19:00 - 20:00 Dinner

Jul 28 (Tue)

08:00 - 09:00 Breakfast

09:00 - 10:00 Udayan Darji: *Generating infinite random graphs*

10:00 - 10:30 Coffee

10:30 - 11:30 Gordon Royle: *Endomorphisms and Cores*

11:40 - 12:10 Lovkush Agarwal: *Uncountably many maximal closed subgroups of Sym(w), via Henson digraphs*

12:10 - 12:40 Michael Kompatscher: *A counterexample on the reconstruction of oligomorphic monoids*

13:00 - 14:00 Lunch at Grey College

14:30 - 15:00 Max Gadouleau: *Transformation semigroups generated by idempotents of defect one*

15:00 - 15:30 Yann Peresse: *Long chains of subsemigroups*

15:30 - 16:00 Coffee

16:00 - 17:00 Igor Dolinka: *Representing semigroups and groups by endomorphisms of Fraïssé limits (Part II)*

17:10 - 18:10 Lionel Van The: *Ramsey-type phenomena from fixed points in compactifications*

19:30 - 20:30 Conference Dinner

Jul 29 (Wed)

08:00 - 09:00 Breakfast

09:00 - 10:00 Michael Pinsker: *Topological clones (Part II)*

10:00 - 10:30 Coffee

10:30 - 11:30 Stuart Margolis: *Translational hulls as the transformation monoid of continuous maps on combinatorial structures*

11:40 - 12:10 J Jonusas: *Topological 2-generation of automorphism groups of homogenous graphs*

12:10 - 12:40 Alonso Castillo-Ramirez: *Memoryless Computation and Universal Simulation*

13:00 - 14:00 Lunch at Grey College

14:30 - 15:00 Michael Giudici: *The classification of 323232-transitive permutation groups*

15:00 - 15:30 Catarina Carvalho: *On a subsemigroup of binary relations*

15:30 - 16:00 Coffee

16:00 - 17:00 Dragan Masulovic: *Categorical Constructions and Ramsey Property*

17:10 - 18:10 Robert Gray: *To be arranged*

19:00 - 20:00 Dinner

Jul 30 (Thu)

08:00 - 09:00 Breakfast and departure

London Mathematical Society EPSRC Durham Symposium

Permutation groups and transformation semigroups

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Abstracts

Ackerman- Ergodic invariant measures as probabilistic structures

In this series of three talks, we report on a program that examines ergodic measures invariant under the logic action. Consider the Borel space of all L-structures with underlying set the natural numbers, where L is a countable language. The symmetric group on the natural numbers acts on this space via the logic action, by permuting the elements of a given structure. We describe how the ergodic probability measures on this space that are invariant under the logic action provide a natural notion of "probabilistic structure". Associated to each such ergodic invariant measure is a complete consistent infinitary theory. It can be shown that these measures fall into two classes: (i) those that concentrate on a single isomorphism class of structures, i.e., a single orbit of the logic action, and (ii) those whose associated infinitary theory has no classical models. In the first case, we characterize those orbits admitting an invariant measure, and in particular describe when such a measure is unique; the latter involves the notion of a highly homogeneous permutation group. We provide sufficient conditions for the second case to occur, leading to new probabilistic constructions of Urysohn space and other structures. The study of such measures is closely tied to the theory of limits of dense graph sequences, or graphons, as in work of Lovász, Szegedy, and others. We describe this connection, and show how the model theory of invariant measures can shed light on the study of graphons. Joint work with Alex Kruckman, Aleksandra Kwiatkowska, Jaroslav Nešetřil, and Jan Reimann. Lecture 1: An overview of ergodic invariant measures as probabilistic structures Lecture 2: Graphons and ergodic invariant measures Lecture 3: Techniques for constructing ergodic invariant measures.

Agarwal- Uncountably many maximal closed subgroups of Sym(w), via Henson digraphs

In Ravello 2013, Macpherson asked whether there are uncountably many maximal closed subgroups of Sym(w), where G is maximal means that G is not equal to Sym(w) and there

are no closed subgroups in between G or Sym(w). In this talk, I will present a positive answer to this question using Henson digraphs.

Anscombe- Generalised measures on free homogeneous structures

In this talk I will discuss how to view free homogeneous structures as `generalised measurable structures', which is a new definition (from my project with Macpherson-Steinhorn-Wolf) generalising the earlier definition of measurable structures (due to Macpherson-Steinhorn). Our main motivating example is the generic triangle-free graph.

Araujo- Groups and semigroups: from a duet to a chorus

To be confirmed

Bentz- How synchronizing are primitive groups?

Synchronization is a property of automata and can be understood as a method of error recovery. An automaton is synchronizing if there is an input sequence which always brings the automaton into a known state irrespectively of the original state of the automaton. Such an instruction set is called a \emph{reset} (or \emph{synchronizing}) word. We can translate this question into the realm of semigroup theory by asking if the transition semigroup associated to the automaton contains a constant map. An important case of this approach is the situation where this semigroup is generated by a permutation group G together with a singular transformation t, both acting on the state set X. The primitivity of the group G is a strong property that ``usually´´ forces synchronization in connection with a non-permutation. Our work examines how usual this situation is. We will present several new results about the synchronization properties of primitive groups, both negative and positive. We will also give an introduction to the graph-based methods used in our proofs. Further details on the computational issues involved in this project along with a variety of problems concerning primitive graphs, graph endomorphisms, and cores of vertex-transitive graphs will be discussed in upcoming talks by Gordon Royle. This is a joint work with {\sc Jo\~{a}o Ara\'{u}jo} (CEMAT Universidade de Lisboa), {\sc Peter J. Cameron} (Mathematical Institute, University of St Andrews), {\sc Gordon Royle} (Centre for the Mathematics of Symmetry and Computation, University of Western Australia), and {\sc Artur Schaefer} (Mathematical Institute, University of St Andrews).

Carvalho- On a subsemigroup of binary relations

We introduce the monoid of surjective hyperoperations, as it appeared in connection with variation of the Constraint Satisfaction Problem. We relate it with the already studied subsemigroups of binary relations, give some of its structural properties and present an array of open questions about its structure.

Castillo-Ramirez- Memoryless Computation and Universal Simulation

Let A be a finite set and n an integer at least 2. Memoryless computation is the study of instructions of A^n (i.e. transformations of A^n with at most one nontrivial coordinate function) and the

semigroups of transformations that they generate. This model of computation has been recently revitalised by several new results, such as the proof by Cameron, Fairbairn and Gadouleau that the full transformation semigroup on A^n may be generated by just n+1 instructions. In this talk we will introduce the concept of 'simulation' as a way of computing transformations of A^n using m instructions that may depend on m-n additional coordinates. A transformation of A^m is n-universal of size m if the instructions induced by its coordinate functions may simulate any transformation of A^n. We will establish that there is no n-universal transformation of size n, but there is one of size n+2. We will also introduce the notions of sequential, parallel and quasi-parallel simulation. This talk is based on joint work with Maximilien Gadouleau

Cherlin- Metrically Homogeneous Graphs of Generic Type

I will discuss the conjectured classification of metrically homogeneous graphs. I will first define precisely what I mean by generic type, then discuss some or all of the following points. * The metrically homogeneous graphs of non-generic type are classified. * The conjectured classification in generic type is that the minimal forbidden structures are either triangles or clique-like constraints * Under a technical assumption called 4-triviality, the allowable patterns of forbidden triangles are known. * The infinite diameter case reduces to the finite diameter case - if the conjecture is correct in finite diameter.

Darji- Generating infinite random graphs

In this talk we discuss a probabilistic algorithm for generating infinite random graphs. It has a probabilistic flavor but at the same time some homogeneous structure seems to be lurking underneath. For example, we characterize when our algorithm generates the Rado graph. Under certain parameters, our process generates infinite random trees. Many interesting problems and connections with homogeneous structures arise. This is joint work with Csaba Bir\xc3\xb3.

Dolinka- Representing semigroups and groups by endomorphisms of Fraïssé limits (Part I)

PART I (Semigroup embeddings): I will begin by giving a summary of the particular results concerning embedding abstract (countable) semigroups into End(M), where M is one of the 'most popular' Fraïssé limits. Then I will describe how this evolved into a general universality result for endomorphism monoids of countably infinite homogeneous structures, obtained in collaboration with D. Mašulović. This result will involve several category-theoretical properties of Fraïssé classes. PART II (Groups - overt & covert): In this part, my departing point will be the observation that, under some relatively mild conditions, a structure is isomorphic to a retract of a Fraïssé limit if and only if it is algebraically closed. Then I will lay out the main points of a recent joint work with R. Gray, J. McPhee, J. Mitchell, and M. Quick, which investigates automorphism groups of graph-like algebraically closed structures, thus representing them as a) maximal subgroups of endomorphism monoids of homogeneous graphs, and as b) Schützenberger groups of non-regular endomorphisms. Along the way, to

provide a proper background, I will develop some basic semigroup-theoretical machinery specialised to endomorphism monoids.

Dolinka- Representing semigroups and groups by endomorphisms of Fraïssé limits (Part II)

PART I (Semigroup embeddings): I will begin by giving a summary of the particular results concerning embedding abstract (countable) semigroups into End(M), where M is one of the 'most popular' Fraïssé limits. Then I will describe how this evolved into a general universality result for endomorphism monoids of countably infinite homogeneous structures, obtained in collaboration with D. Mašulović. This result will involve several category-theoretical properties of Fraïssé classes. PART II (Groups - overt & covert): In this part, my departing point will be the observation that, under some relatively mild conditions, a structure is isomorphic to a retract of a Fraïssé limit if and only if it is algebraically closed. Then I will lay out the main points of a recent joint work with R. Gray, J. McPhee, J. Mitchell, and M. Quick, which investigates automorphism groups of graph-like algebraically closed structures, thus representing them as a) maximal subgroups of endomorphism monoids of homogeneous graphs, and as b) Schützenberger groups of non-regular endomorphisms. Along the way, to provide a proper background, I will develop some basic semigroup-theoretical machinery specialised to endomorphism monoids.

Droste- The normal subsemigroups of the monoid of injective maps

We consider the monoid Inj(M) of injective self-maps of a set M and want to determine its normal subsemigroups by numerical invariants. This was established by Mesyan in 2012 if M is countable. Here we obtain an explicit description of all normal subsemigroups of Inj(M) for any uncountable set M. Joint work with Rüdiger Göbel (Essen).

East- Linear sandwich semigroups

Let Mmn denote the set of all $m\times n$ matrices over a field F, and fix some $n\times m$ matrix $A\in Mnm$. An associative operation $\star$ may be defined on Mmn by $X\star Y=XAY$ for all $X,Y\in Mmn$, and the resulting ``sandwich semigroup'' is denoted $MAmn$. It seems these linear sandwich semigroups were introduced by Lyapin in his 1960 monograph, and they are related to the so-called generalized matrix algebras of Brown (1955), but they have not received a great deal of attention since some early papers by Magill and Subbiah in the 60s and 70s. In this talk, I will report on joint work with Igor Dolinka (Novi Sad) in which we investigate certain combinatorial questions regarding the linear sandwich semigroups, including: regularity, Green's relations, ideals, rank and idempotent rank. We also outline a general framework for studying more general sandwich semigroups: the context is a kind of partial semigroup related to Ehresmann-style arrows-only categories.

Egri-Nagy- Finite Diagram Semigroups: Extending the Computational Horizon

Diagram semigroups are interesting algebraic and combinatorial objects, several types of them originating from questions in computer science and in physics. Here we describe diagram semigroups in a general framework and extend our computational knowledge of

them. The generated data set is replete with surprising observations raising many open questions for further theoretical research. Joint work with James East, Andrew R. Francis and James D. Mitchell.

Freer- Ergodic invariant measures as probabilistic structures

Title: Ergodic invariant measures as probabilistic structures Nathanael Ackerman, Cameron Freer, Rehana Patel Abstract: In this series of three talks, we report on a program that examines ergodic measures invariant under the logic action. Consider the Borel space of all L-structures with underlying set the natural numbers, where L is a countable language. The symmetric group on the natural numbers acts on this space via the logic action, by permuting the elements of a given structure. We describe how the ergodic probability measures on this space that are invariant under the logic action provide a natural notion of "probabilistic structure". Associated to each such ergodic invariant measure is a complete consistent infinitary theory. It can be shown that these measures fall into two classes: (i) those that concentrate on a single isomorphism class of structures, i.e., a single orbit of the logic action, and (ii) those whose associated infinitary theory has no classical models. In the first case, we characterize those orbits admitting an invariant measure, and in particular describe when such a measure is unique; the latter involves the notion of a highly homogeneous permutation group. We provide sufficient conditions for the second case to occur, leading to new probabilistic constructions of Urysohn space and other structures. The study of such measures is closely tied to the theory of limits of dense graph sequences, or graphons, as in work of Lovász, Szegedy, and others. We describe this connection, and show how the model theory of invariant measures can shed light on the study of graphons. Joint work with Alex Kruckman, Aleksandra Kwiatkowska, Jaroslav Nešetřil, and Jan Reimann. Lecture 1: An overview of ergodic invariant measures as probabilistic structures Lecture 2: Graphons and ergodic invariant measures Lecture 3: Techniques for constructing ergodic invariant measure

Gadouleau- Transformation semigroups generated by idempotents of defect one

It is well known that the semigroup of all singular transformations of a finite set is generated by idempotents of defect one. Such a transformation can be seen as an arc in a directed graph. We then study properties of semigroups generated by idempotents of defect one based on their digraph representation. We will first study some algebraic properties and then investigate the maximum length of a word using these generators.

Giudici- The classification of $\frac{3}{2}$-transitive permutation groups

A permutation group on a set Ω is called 3

2-transitive if it is transitive and for all $\alpha \in \Omega$ the orbits of the point stabiliser $G\alpha$ on $\Omega \setminus \{\alpha\}$ all have the same length. Wielandt showed that a finite $\frac{3}{2}$-transitive group is either Frobenius or

primitive. The talk will discuss the recent classification of all primitive $\frac{3}{2}$-transitive permutation groups that is the result of work by various subsets of Bamberg, Giudici, Liebeck, Saxl, Praeger and Tiep.

Gray- To be confirmed

Higgins- Using transformations to embed finite semigroups of a certain type in 2-generated finite semigroups of the same type.

We use transformation semigroups to show how finite semigroups in a particular class may be embedded in 2-generated finite semigroups of the same class. In particular, any finite orthodox semigroup (a regular semigroup in which idempotents form a subsemigroup) may be embedded in a 2-generated finite orthodox semigroup. Along the way we make use of the properties of a certain peculiar string of numbers known as the Mian-Chowla sequence.

Hubicka- Ramsey Classes by Partite Construction (Part I)

The first lecture will focus on the Partite Construction - a technique of proving Ramsey property of a given class introduced by Nesetril and Rodl. I will show how to extend the technique to classes with algebraic closures and give examples of classes where the Ramsey Property can be shown by application of this method. The second lecture will follow by extending the Partite Construction to classes with forbidden homomorphic images. I will show how this leads to more systematic approach of finding new Ramsey lifts.

Hubicka- Ramsey Classes by Partite Construction (Part II)

The first lecture will focus on the Partite Construction - a technique of proving Ramsey property of a given class introduced by Nesetril and Rodl. I will show how to extend the technique to classes with algebraic closures and give examples of classes where the Ramsey Property can be shown by application of this method. The second lecture will follow by extending the Partite Construction to classes with forbidden homomorphic images. I will show how this leads to more systematic approach of finding new Ramsey lifts.

Hyde- 2-Generation In Groups Of Homeomorphisms Of The Cantor Set

Let *S* be a set of homeomorphisms of the Cantor set. We will call *S* vigorous if and only if for any *A* a non-empty clopen subset of the Cantor set and any *B* and *C* non-empty proper clopen subsets of *A* there exists *g* in *S* with the support of *g* contained in *A* and with *Bg* a subset of *C*. Our main theorem is that finitely generated simple vigorous groups of homeomorphisms of the Cantor set are 2-generated. We will give sufficient conditions for a group of homeomorphism to be vigorous and give some examples

Jonusa- Topological 2-generation of automorphism groups of homogenous graphs

To be confirmed

Kambites- Amenability and geometry of semigroups

I will discuss some recent joint research with Robert Gray on the connection between amenability, Følner conditions and the geometry of finitely generated semigroups.

Kinyon - Automorphic loops and their associated permutation groups

An important permutation group associated with a loop Q is its multiplication group $\mathrm{Mlt}(Q)$ generated by all left translations $L_x : y \mapsto xy$ and all right translations $R_x : y \mapsto yx$. The stabilizer of the identity element of Q is the inner mapping group $\mathrm{Inn}(Q)$. A loop is \emph{automorphic} if every inner mapping is an automorphism of Q. Groups and commutative Moufang loops are examples of automorphic loops, but there are many others as well. The outstanding open problem in the theory of automorphic is to determine if there are any finite, nonassociative, simple automorphic loops. Simplicity of a loop Q is characterized by $\mathrm{Mlt}(Q)$ acting primitively on Q, and thus one approach to searching for simple loops is to use an O'Nan-Scott attack. In this talk, I will give some background on automorphic loops and describe the current state of the art in the search for finite, nonassociative, simple automorphic loops.

Kompatscher- A counterexample on the reconstruction of oligomorphic monoids

How much about a structure is coded into its automorphism group? This question has been intensely studied for omega-categorical structures. It is well known that two omega-categorical structures are first order bi-interpretable iff their automorphism groups are topologically isomorphic, endowed with the topology of pointwise convergence. Does this theorem still hold if we request the automorphism groups only to be isomorphic as abstract groups? Or in other words, can we reconstruct the topology of an oligomorphic permutation group from its algebraic structure? In 1990 Evans and Hewitt constructed an example that negates this question. A natural object that carries more information about a structure than its automorphism group is its endomorphism monoid. A result of Bodirsky and Junker states that, under some additional assumptions, two omega-categorical structures are positive existentially bi-interpretable iff their endomorphism monoids are topologically isomorphic. Again the question arises if we can neglect the topology. In my talk I would like to present the oligomorphic group constructed by Evans and Hewitt and show that also its closure as topological monoid and its closure as topological clone have no reconstruction. This result is a joint work with Manuel Bodirsky, David Evans and Michael Pinsker.

Loughlin- The Brauer Project

The Brauer project started as a small undertaking to count and understand idempotents in certain semigroups of diagrams. I'll focus on recent developments in understanding the Jones monoids and some close relatives, including a newly-discovered family of semigroups,

and there will be an emphasis on developing the theory into memory-efficient working algorithms for counting and indexing idempotents, which are of independent interest.

Macpherson- To be confirmed

Margolis- Translational hulls as the transformation monoid of continuous maps on combinatorial structures

A finite aperiodic 0-simple semigroup is by Rees Theorem given by a {0,1} matrix C. By viewing C as an incidence structure, we gain a perspective that allows interactions between group theory, semigroup theory and combinatorics. We look at 35 year old results of Jeff Dinitz and the speaker in the case that C is the incidence matrix of a block design. The translational hull, is then the transformation monoid of all continuous partial maps on the design. This is the monoid of all partial functions on the points of the design such that the inverse image of any block is either empty or another block. We give interesting connections between the structure of the translational hull and the parameters of the design. In particular, we give a generalization of the fundamental theorem of projective geometry

Masulovic- Categorical Constructions and Ramsey Property

It was obvious from the beginning that structural Ramsey property is a categorical property: it depends not only on the choice of objects, but also on the choice of morphisms involved. In this talk we explicitely put the Ramsey property and the dual Ramsey property in the context of categories of finite structures and investigate the invariance of these properties under some standard categorical constructions. We use elementary category theory to generalize some combinatorial results and using the machinery of very basic category theory provide new combinatorial statements (whose formulations do not refer to category-theoretic notions).

Nehaniv- Coproducts for Permutation Groups, Transformation Semigroups, Automata and Related Categories

The structure of coproducts of groups, monoids and semigroups is well-known: they are the so-called ``free products'' satisfying a universal mapping property and their elements can be written in a canonical form. Surprisingly, the structure of coproducts for faithful representations of groups by permutations, or for monoids and semigroups by transformations appears not to have been described in the literature. Indeed they may fail to exist (in some degenerate cases) for transformation semigroups. Moreover, the most obvious guesses of what the coproduct should be in these categories turn out to be wrong. Here we completely describe the structure of coproducts (including canonical forms for their state sets) in the categories of permutation groups, transformation monoids and transformation semigroups, with or without base point and also for partial transformation semigroups. It turns out this also allows us to completely describe the structure of coproducts of automata (whether in the categories of deterministic and complete, or partial automata), i.e. for discrete dynamical systems with inputs, leading to applications for

computer science. This is joint work with Fariba Karimi and funded under the EC FP7 BIOMICS project.

Patel- Ergodic invariant measures as probabilistic structures (Nathanael Ackerman, Cameron Freer, Rehana Patel)

In this series of three talks, we report on a program that examines ergodic measures invariant under the logic action. Consider the Borel space of all L-structures with underlying set the natural numbers, where L is a countable language. The symmetric group on the natural numbers acts on this space via the logic action, by permuting the elements of a given structure. We describe how the ergodic probability measures on this space that are invariant under the logic action provide a natural notion of "probabilistic structure". Associated to each such ergodic invariant measure is a complete consistent infinitary theory. It can be shown that these measures fall into two classes: (i) those that concentrate on a single isomorphism class of structures, i.e., a single orbit of the logic action, and (ii) those whose associated infinitary theory has no classical models. In the first case, we characterize those orbits admitting an invariant measure, and in particular describe when such a measure is unique; the latter involves the notion of a highly homogeneous permutation group. We provide sufficient conditions for the second case to occur, leading to new probabilistic constructions of Urysohn space and other structures. The study of such measures is closely tied to the theory of limits of dense graph sequences, or graphons, as in work of Lovász, Szegedy, and others. We describe this connection, and show how the model theory of invariant measures can shed light on the study of graphons. Joint work with Alex Kruckman, Aleksandra Kwiatkowska, Jaroslav Nešetřil, and Jan Reimann. Lecture 1: An overview of ergodic invariant measures as probabilistic structures Lecture 2: Graphons and ergodic invariant measures Lecture 3: Techniques for constructing ergodic invariant measures

Pech- Reconstructing the topology of polymorphism clones

Every clone of functions comes naturally equipped with a topology-the topology of pointwise convergence. A clone C is said to have automatic homeomorphicity with respect to a class K of clones, if every clone-isomorphism of C to a member of K is already a homeomorphism (with respect to the topology of pointwise convergence). I am going to talk about automatic homeomorphicity-properties for polymorphism clones of countable homogeneous relational structures. The results base on (and extend) previous results by Bodirsky, Pinsker, and Pongrácz.

Peresse- Long chains of subsemigroups

The length of a semigroup S is defined to be the largest size of a chain of subsemigroups of S. An exact formula for the length of the symmetric group on n points was found by Cameron, Solomon and Turull; the length is roughly 3n/2. In general, it follows by Lagrange's Theorem that the length of a group is at most the logarithm of the group order. Semigroups refuse to be as well-behaved. The only valid upper bound for the length of an arbitrary semigroup is its size. For example, any zero-semigroup has length equal to its size. Even for less degenerate and more natural examples of semigroups, the contrast to groups is

noticable. We will see that the length of the full transformation semigroup on n points, the semigroup analogue to the symmetric group, is asymptotically at least a constant multiple of its size.

Pinsker- Topological clones (Part I)

Every algebra carries, in addition to its algebraic structure, a natural topological structure: this structure is given by the topology of pointwise convergence on its term functions. Topological clones are the abstract algebraic and topological objects which capture both the algebraic and topological structure of algebras, similarly to topological groups which appear as the algebraic and topological abstraction of permutation groups. In my two lectures I am going to explain what we can tell about an algebra from its topological clone. This will lead me in particular into complexity theory, where certain computational problems, called Constraint Satisfaction Problems, are investigated systematically via their polymorphism algebras, and subsequently via topological clones. I will moreover address the often non-trivial interference between the algebraic and the topological structure of algebras. Finally, I will show how the algebraic modelling of function clones can be altered in order to be more suitable for constraint satisfaction.

Pinsker- Topological clones (Part II)

Every algebra carries, in addition to its algebraic structure, a natural topological structure: this structure is given by the topology of pointwise convergence on its term functions. Topological clones are the abstract algebraic and topological objects which capture both the algebraic and topological structure of algebras, similarly to topological groups which appear as the algebraic and topological abstraction of permutation groups. In my two lectures I am going to explain what we can tell about an algebra from its topological clone. This will lead me in particular into complexity theory, where certain computational problems, called Constraint Satisfaction Problems, are investigated systematically via their polymorphism algebras, and subsequently via topological clones. I will moreover address the often non-trivial interference between the algebraic and the topological structure of algebras. Finally, I will show how the algebraic modelling of function clones can be altered in order to be more suitable for constraint satisfaction.

Rosendal- Large scale geometry of automorphism groups (Part I)

The large scale geometry of finitely or compactly generated groups has long been a central part of geometry, topology and group theory. An abstract approach to certain aspects of large scale geometry is given by the coarse spaces due to J. Roe of which finitely or compactly generated groups, metric spaces and Banach spaces are particular examples. By analogy with a classical description of the left-invariant uniformity, we define a canonical left-invariant coarse structure on every topological group. This coincides with the previously mentioned cases, but also identifies natural structure in more general topological groups

such as homeomorphism groups and other topological transformation groups. We develop this theory in the particular setting of automorphism groups of first order structures, which will allow us to identify a canonical geometry of the model theoretical structures themselves.

Rosendal- Large scale geometry of automorphism groups (Part II)

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Rosendal- Large scale geometry of automorphism groups (Part III)

The large scale geometry of finitely or compactly generated groups has long been a central part of geometry, topology and group theory. An abstract approach to certain aspects of large scale geometry is given by the coarse spaces due to J. Roe of which finitely or compactly generated groups, metric spaces and Banach spaces are particular examples. By analogy with a classical description of the left-invariant uniformity, we define a canonical left-invariant coarse structure on every topological group. This coincides with the previously mentioned cases, but also identifies natural structure in more general topological groups such as homeomorphism groups and other topological transformation groups. We develop this theory in the particular setting of automorphism groups of first order structures, which will allow us to identify a canonical geometry of the model theoretical structures themselves.

Royle- Endomorphisms and Cores

In this talk, I will continue the general theme of the first talk, but now with a focus on the *core* of a graph G, which is the unique minimum-sized induced subgraph of G that is the image of some endomorphism of G. I will discuss some long-standing open problems relating to the cores of vertex-transitive graphs, strongly-regular graphs and Cayley graphs, and report on some recent work on these problems. In this talk, I will discuss some computational approaches to resolving this question for small orders along with some infinite families of examples, whose discovery relied on examining the computational data.

Royle- Endomorphisms and Synchronisation

In an earlier talk, Wolfram Bentz discussed the question of whether a finite primitive permutation group is necessarily *almost-synchronising* (that is, synchronises every non-uniform transformation) and explained how this reduces to finding endomorphisms of vertex-primitive graphs. In this talk, I will discuss some computational approaches to resolving this question for small orders along with some infinite families of examples, whose discovery relied on examining the computational data.

Schaefer- Synchronization Theory and Links to Combinatorics

If we are given a transformation semigroup S on n points, the graph Gr(S) has vertex set 1,...,n where two vertices v,w are adjacent, if there is no f in S with vf=wf. Moreover, a graph X is called a hull, if X=Gr(S), where S is its endomorphism monoid. This construction and, in particular, hulls were introduced by Cameron and Kazanidis and have been used to establish the important connection between synchronization theory and graph endomorphisms. Their theorem says that a group G is synchronizing, if and only if there is no G-invariant graph which is a hull, admitting singular endomorphisms. In this talk, we will discuss the major role of hulls for synchronization theory, interpret graph endomorphisms as well known combinatorial objects, and discuss some structural properties of some non-synchronizing semigroups. Firstly, we will talk about hulls, provide examples of hulls and non-hulls and discuss (minimal) generating sets for Gr(S). Secondly, we will consider Hamming graphs, which are hulls, and related graphs. In particularly, we will link their endomorphisms to the existence of Latin hypercuboids of class R, to minimum distance separable mixed codes and to tilings. Ultimately, we introduce a new set of examples of non-synchronizing semigroups induced by tilings and provide general properties of these semigroups. Consequently, such a semigroup can be decomposed into a disjoint union of subsemigroups.

Siniora- To be confirmed

Solecki- Homogeneity of the pseudo-arc through permutation groups

The pseudo-arc is the generic compact connected subset of the plane (or the Hilbert cube). By a fundamental result of Bing, it is homogeneous as a topological space. By work of Irwin and myself, the pseudo-arc is represented as a quotient of a dual Fraisse limit, which allows for a discretization of a continuous situation and makes it possible to apply combinatorial/permutation group methods. In this joint work with Tsankov, we determine the correct partial homogeneity of the dual Fraisse limit. Further, we prove a transfer theorem, through which we recover Bing's homogeneity of the pseudo-arc from our partial homogeneity of the dual Fraisse limit.

Spiga- To be confirmed

Steinberg- The representation theory of finite monoids (Part I)

I will provide an introduction to the representation theory of finite monoids focusing on irreducible representations, character theory and applications to combinatorics and Markov chains. Important examples such as the full transformation monoid and the monoid of nxn matrices over a finite field will be used as examples.

Steinberg- The representation theory of finite monoids (Part II)

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Tent- Sharply 3-transitive groups

The finite sharply 2- and 3-transitive groups were classified by Zassenhaus in the 1930s. Up to finitely many exceptions they all arise from finite fields. It was an open question whether the same is true in the infinite situation. In my talk I will explain and answer this question.

Thomas- Invariant random subgroups of locally finite groups

Let G be a countable discrete group and let Sub_G be the compact space of subgroups $H \leqslant G$. Then a probability measure ν on Sub_G which is invariant under the conjugation action of G on Sub_G is called an invariant random subgroup. In this talk, I will explain how the pointwise ergodic theorem reduces questions concerning the invariant random subgroups of locally finite groups to problems in the asymptotic theory of finite permutation groups

Truss- Definability properties of the monoid of endomorphisms of the rational numbers

I write M for the monoid of self-embeddings of the rationals, G for its automorphism group, and E for the monoid of all its endomorphisms. Thus G is a subset of M which in turn is a subset of E. I study various definable subsets of these monoids, and discuss the relationship between them. One difference for instance is that in E it is easy to represent the individual rational numbers (via constant maps), but in M this is less obvious. This work is directed at reconstruction results for the polymorphism clones on the rationals under either the strict or reflexive relation (joint work with Edith Vargas Garcia).

Tsankov- Banach representations of dynamical systems and model theory

It is well-known that the automorphism group of an omega-categorical structure encodes all model-theoretic information about the structure. Recently, an interesting correspondence

has been discovered between properties of the theory (stability, omega-stability, NIP) and classes of Banach spaces on which certain dynamical systems (the automorphism group acting on type spaces over the model) can be represented. In the stable case, those dynamical systems also carry the structure of a semigroup that can be exploited. I will discuss what is known about this correspondence as well as some open questions. This is joint work with Itaï Ben Yaacov and Tomás Ibarlucía.

Van The- Ramsey-type phenomena from fixed points in compactifications

Ramsey theory (which is, roughly, the study of the necessary appearance of very organized substructures inside of any sufficiently large structure) has lately largely benefited from its connection to various other fields, especially dynamics and functional analysis. In this talk, I will illustrate this further by showing how the existence of fixed points in certain group compactifications allows to derive new Ramsey-type results.

Vargas-Garcia- Introduction to the reconstruction for the topological monoid of the rationals.

\emph{Transformation Monoids} carry a natural topology, provided by the topology of point-wise convergence, with respect to which the composition is continuous. A \emph{Topological Monoid} is an abstract monoid equipped with a topology under which the composition is continuous. The endomorphism monoids $End(\mathrm{A})$ of a relational structure A are viewed abstractly as a topological monoids whose topology is the natural topology. Moreover, they are the \emph{closed} submonoids of the space of all unary functions on A. We study when $End(\mathrm{Q},\leq)$ has the property that every monoid isomorphism to the endomorphism monoid of other relational structure B is automatically a homeomorphism.

Volkov - Representations of finite J-trivial monoids and finite block-groups by transformations and relations

Finite J-trivial monoids and finite block-groups play a distinguished role in the algebraic theory of regular languages. In turn, several purely algebraic representations of these monoids by transformations and binary relations have been established by language-theoretic tools, and moreover, mastering direct proofs for these representation results appears to constitute quite a serious challenge. We overview the area, focusing on recent advances and questions that still remain open.

Volkov- Cerny's type problem for transformation semigroups

The famous \v{C}ern\'{y} conjecture about synchronizing automata can be restated in terms of transformation semigroups as follows: for each subset Σ of the full transformation monoid on the n-element set, if the subsemigroup S generated by Σ contains a constant transformation, then already a product of some $(n-1)2$ transformations in Σ is a constant. Since the problem has proved to be hard, it seems to be reasonable to approach it by imposing some natural constraints on the transformations in Σ or on the subsemigroup S as a whole. Several partial results in the area fit into this scheme; we survey them and comment on possible next steps in this line of research. (2) Cerny's type problem for transformation semigroups The famous \v{C}ern\'{y} conjecture about synchronizing automata can be restated in terms of transformation semigroups as follows: for each subset Σ of the full transformation monoid on the n-element set, if the subsemigroup S generated by Σ contains a constant transformation, then already a product of some $(n-1)2$ transformations in Σ is a constant. Since the problem has proved to be hard, it seems to be reasonable to approach it by imposing some natural constraints on the transformations in Σ or on the subsemigroup S as a whole. Several partial results in the area fit into this scheme; we survey them and comment on possible next steps in this line of research

London Mathematical Society -- EPSRC Durham Symposium

Permutation groups and transformation semigroups

2015-07-20 to 2015-07-30

Registered Participants

Nate Ackerman	Harvard
Lovkush Agarwal	University of Leeds
Will Anscombe	University of Leeds
João Araujo	Universidade Aberta, Portugal
Wolfram Bentz	Universidade de Lisboa
David Bradley-Williams	University of Leeds
John Britnell	Imperial College London
Peter Cameron	St Andrews
Catarina Carvalho	University of Hertfordshire
Alonso Castillo-Ramirez	University of Durham
Gregory Cherlin	Rutgers
Udayan Darji	University of Louisville
Igor Dolinka	Novi Sad
Manfred Droste	Leipzig
James East	University of Western Sydney
Attila Egri-Nagy	University of Western Sydney
David Evans	University of East Anglia
John Fountain	York
Cameron Freer	MIT
Max Gadouleau	Durham

Michael Giudici	University of Western Australia
Victoria Gould	University of York
Robert Gray	University of East Anglia
Peter Higgins	University of Essex
Jan Hubicka	Calgary
James Hyde	University of St Andrews
Julius Jonusas	St Andrews
Mark Kambites	University of Manchester
Michael Kinyon	University of Denver
Anja Komatar	University of Leeds
Michael Kompatscher	Vienna University of Technology
Nicholas Loughlin	Newcastle University
Dugald Macpherson	Leeds
Stuart Margolis	Bar Ilan University
Dragan Masulovic	Novi Sad
James Mitchell	St Andrews
Michal Morayne	Wroclaw
Chrystopher Nehaniv	University of Hertfordshire
Jaroslav Nesetril	Charles University, Prague
Rehana Patel	Olin College
Christian Pech	Technical University of Dresden
Maja Pech	Novi Sad
Yann Peresse	University of Hertfordshire
Michael Pinsker	University of Diderot
Cheryl Praeger	The University of Western Australia
Tom Quinn-Gregson	University of York

Colva Roney-Dougal	University of St Andrews
Christian Rosendal	University of Illinois at Chicago
Gordon Royle	University of Western Australia
Artur Schaefer	University of St Andrews
Slawomir Solecki	University of Illinois at Urbana-Champaign
Pablo Spiga	Università di Milano-Bicocca
Benjamin Steinberg	CCNY
Katrin Tent	Munster
Simon Thomas	Rutgers
Michael Torpey	St Andrews
John Truss	University of Leeds
Todor Tsankov	Diderot
Lionel Van The	Aix-Marseille
Edith Vargas-Garcia	University of Leeds
Mikhail Volkov	Ekaterinburg
Wilf Wilson	University of St Andrews

London Mathematical Society EPSRC Durham Symposium

Monday 20th July - Thursday 30th July 2015

Permutation groups and transformation semigroups
GREY COLLEGE INFORMATION

Meal Times:	Breakfast	7.30-8.00 Continental, 8.00-8.45 Cooked and Continental
	Lunch	13.00-14.00
	Tea & Coffee	Available continuously in JCR.
	Dinner	19.00

(On the day of arrival, sandwiches will be available behind the bar for latecomers.) Breakfast will be served in the Main Dining Area. Materials for making early morning tea and coffee will be provided in all en suite rooms.

- *Welcome Wine Reception*: Tuesday 21 July 18:15
- *Conference Dinner*: Tuesday 28th July 19:30

Bar facilities: 7.00–11.00pm weekdays and Saturdays. 7.00-10.30pm Sundays. The bar will remain open until midnight for the Conference Dinner.

No Smoking: Smoking is not permitted within the college. There is a designated seated area for smokers situated on the wood side of Grey between the Main building and Holgate House. Please note that smoke detectors in rooms are highly sensitive. Do not tamper with the smoke alarms - they will activate.

Telephone: The College telephone number is Durham 0191 334 5900. There is a public coin telephone near Main Reception. Please ask the receptionist for directions.

Mail: For outgoing mail there is a post box at the entrance to the main Hollingside building. Collections are made daily at 4.15 p.m. Incoming mail will be pinned to notice boards in JCR. Stamps are on sale at Reception.

Common Room: The Junior Common Room will be available for the use of members of the Symposium. Tea and coffee will be available.

Valuables: Members of the Symposium wishing to have valuables locked away should enquire at the Accounts Office during office hours. There is limited space and access is restricted to the following hours: Mon-Tues 9-4pm, Wed- Fri 9-1pm. There is no weekend access

Newspapers: Newspapers will be provided in the JCR.

Laundry: Washing machines are available on a 'do it yourself' basis. Washing and drying keys for the machines can be obtained at reception (no charge applicable). Note that the washer automatically adds powder when the washing key is inserted.

If you require any bathroom supplies replenishing in your room or you require any assistance please do not hesitate to ask at the College Reception.

Recreation, Entertainments and Tourist Information:

Grey College have Croquet equipment available should you wish to arrange a tournament for delegates. Please ask at the College reception for further details.

Facilities for tennis, badminton and table tennis may be available - ask at Symposium Office, Department of Mathematical Sciences.

There are many pleasant walks to be had by the river and in the woods behind Grey College and there are facilities for boating at Elvet Bridge.

There is also a wide variety of entertainments available in Newcastle which is approximately 15 minutes away from Durham by train.

Information and a selection of brochures on events taking place at local theatres, cinemas, night clubs etc., as well as information on local places of interest (including the Cathedral and local church services) is displayed on the noticeboards in the main Hollingside building and from the table on the concourse.

If you would like to visit Durham Castle, guided tours are available for members of the public for a small charge.

Departure: It is most important that all members of the Symposium should pack their luggage and vacate their rooms by 10.00 a.m. on the morning of departure even if staying for lunch. A luggage room will be available if you need to store items temporarily on your day of departure.
Please ensure you return your key to Reception before 10am.

LOCAL INFORMATION

Railway Timetables:

Available from Grey College Reception and the Symposium Office, Department of Mathematical Sciences. For Rail enquiries telephone 08457 484950 or available from the web, visit: *www.nationalrail.co.uk*.

Taxis:	Paddy's		0191 3866662
	Pratts		0191 3860700
Banks:	Market Place:	Barclays, Lloyds, HSBC, National Westminster.	
	New Elvet:	Barclays, Lloyds, HSBC.	
Travel Agents:			
	Dawson and Sanderon		0191 3750700
	Thomas Cook, Market Place		0845 3089266
Post Office:	Silver Street.		
Tourist Information Office:			03000 262626
Local Doctor:	Claypath Medical Practice, Claypath		0191 3332830
Hospital:	University Hospital of North Durham		0191 3332333

This sheet is supplied by the Office of the Department of Mathematical Sciences

Updated March 2015

London Mathematical Society EPSRC Durham Symposium

MATHEMATICAL SCIENCES DEPARTMENTAL INFORMATION

Lecture Rooms

Main lectures and large seminars will be held in room CG93

Symposium Office:

Room CM201 will be used as a Symposium Office.

Notice Board

The notice board is located at the main entrance to the Department of Mathematical Sciences.

Lecture Programme

As distributed and also displayed on the notice board. Details of less formal talks will be posted on the notice board.

Tea and Coffee

Coffee and biscuits will be served in The Chem Cafe immediately outside CG93 every day as advertised on the lecture programme. [Tea and filter coffee will be available at any time in the JCR, Grey College.]

Library Facilities

***University Library**:* See separate information sheet.

Xeroxing Facilities

Material will be photocopied at 5p per copy (paid in advance). Work left in the Symposium Office (CM201) before 10.30 a.m. will usually be available for collection in the Symposium Office before 4.30 p.m. and work left before 3.00 p.m. will usually be available the following morning.

Mail

Incoming mail will be delivered to the Symposium Office (CM201). Should you be expecting any mail during your stay in Durham, please check with Symposium Office staff. For outgoing mail there is a post box just outside the Reception area of the Science Site. Collections are made at 12.00 noon and 5.15 p.m. (Mon.-Fri.), 12.00 noon (Saturday).

Telephone

Maths Office

Computing facilities

See separate sheet.

This sheet is supplied by the Office of the Department of Mathematical Sciences.

Durham University
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Visiting Durham University Library

I am not a member of the University. Can I visit Durham University Library?

If you are not a member of Durham University, you can still visit the Library. Firstly, speak to a member of staff at the visitor window or service desk. You will be asked to produce some personal identification. Identification should be photographic, such as a passport, driving licence or rail card, or an official document or letter bearing your current address. Ensure that you visit during Help and Information desk opening hours to ensure that staff can assist you. View our opening hours at **www.durham.ac.uk/library/using/opening/**

Can I use Library services and resources?

As a day visitor to the Library, you can use the Library on a reference basis – this means you are welcome to look at, read and photocopy items in the Library collection during your visit.

How do I use the Library photocopiers?

You are welcome to use Library photocopying facilities providing that you are copying material for personal use. Purchase a photocopying card from the the vending machine to use the photocopiers.

Can I use a computer and access electronic resources?

Durham University Library is able to provide limited access to electronic resources for visitors. After entering the Library, speak to a member of staff at the Help and Information desk to register to use our visitor access computer service. Once you have registered, you will be given login details to use a dedicated visitor PC.

When you log in, a web browser will open which will allow you access to some of the Library's online resources, where vendor licenses permit. If you have a USB memory drive, you can use this to save files from the internet.

As a visitor, you will not be able to print items or access any other software available to full University members (such as Microsoft Office).

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Regular visitors

Reference access

If you are likely to be a regular visitor to Durham University Library, you may register for a Durham University visitor campus card free of charge, which will allow you reference access to the Library. Inspire passport holders and undergraduates from other UK higher education institutions may also register for reference access.

Borrowing access

Durham University Library is also part of a number of reciprocal schemes, through which we allow some members of other institutions borrowing access to the Library. Visitors with borrowing access are unable to borrow items from the Short Loan Collection.

Borrowing access schemes currently in place are:

- SCONUL Access scheme – borrowing access is offered to members of staff, postgraduates and part-time and distance learning students SCONUL Access by email which the visitor prints out & brings to the library
- Teachers of schools in partnership with the School of Education
- Durham Tees Valley Health Alliance

To register for borrowing access, fill in a campus card application form, available from the Help and Information desk or on our website: **www.durham.ac.uk/library/visitors**

Personal subscriptions and corporate membership

Borrowing access is also available to individuals and organisations by subscription, for which there is a charge. Please see the Library Charges guide for further details.

Business, educational or charitable organisations who wish more than one person to become members of the Library can apply for corporate membership by writing to the Librarian, Jon Purcell.

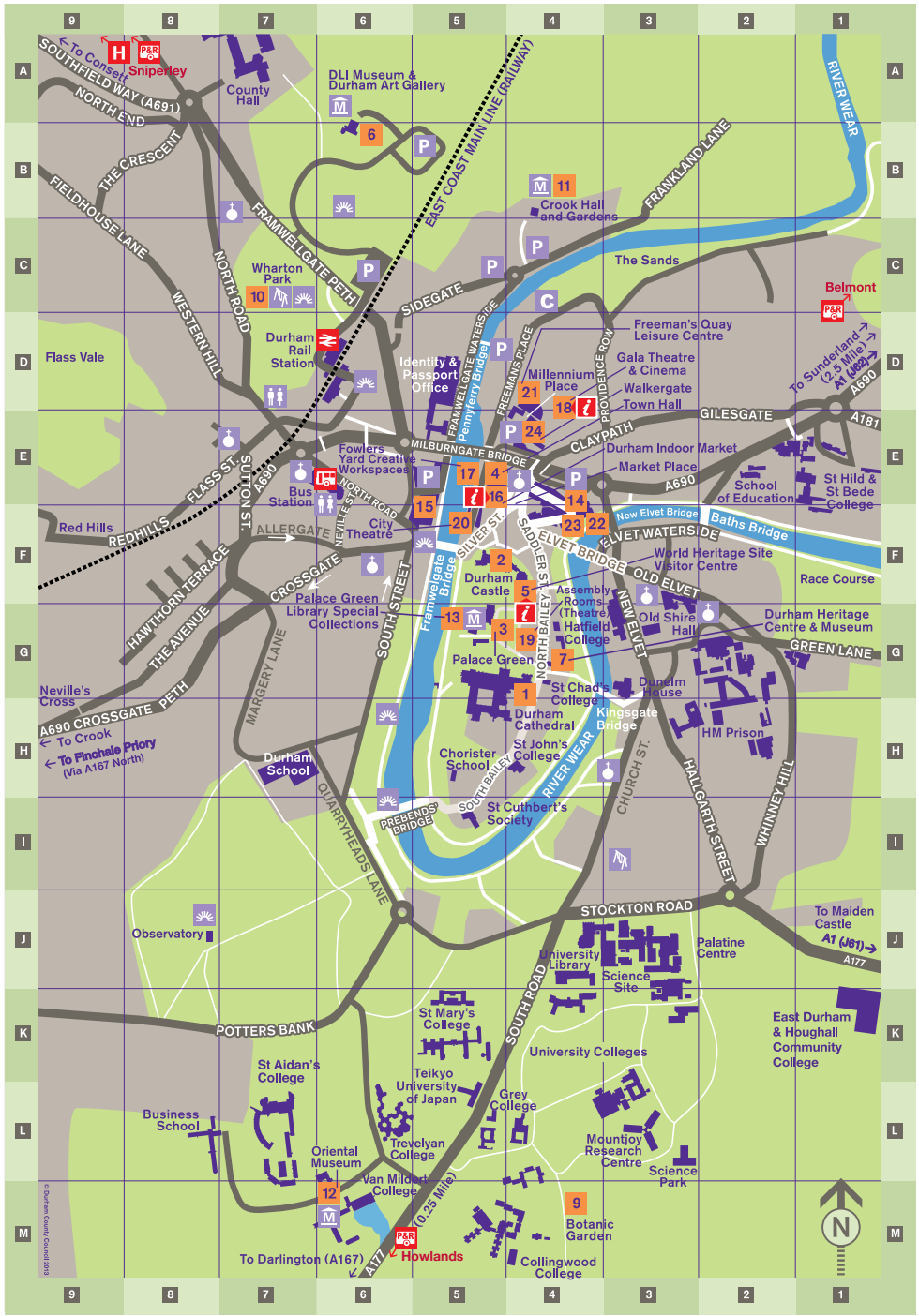
Alternatively, you can apply to register as a subscription borrower by speaking to a member of Library staff and filling in a campus card application form.

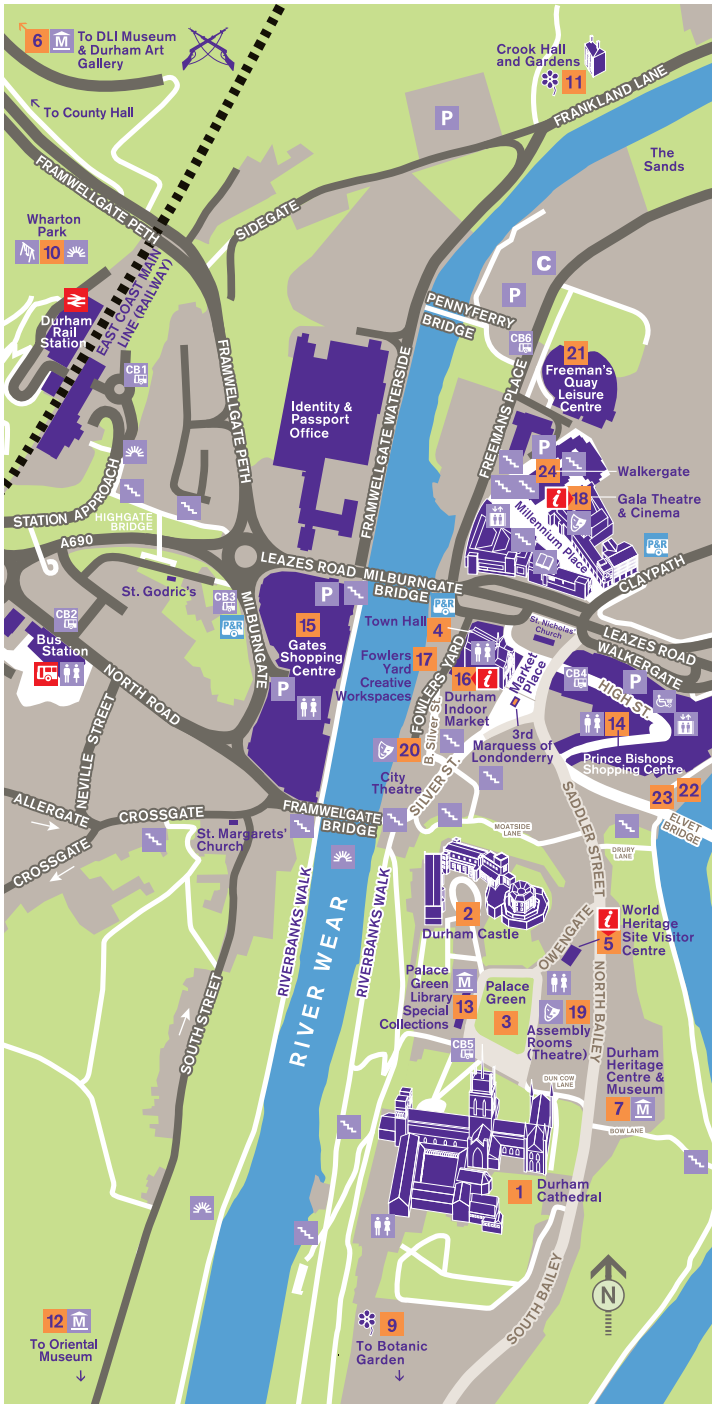
I’ve filled in a campus card application form. What happens next?

After your campus card application form is returned to us, it is processed by the Library and Computing and Information Services which may take a few days. You will be contacted when your card is available for collection from the Library.

www.durham.ac.uk/library/visitors/

This is durham City Map





- University Hospital — A9
- Durham Rail Station — D6
- North Road Bus Station — E6
- Visitor Information Points

- Park & Ride Bus Stops
- Car Park
- Coach Park
- Shopmobility
- Library
- Toilets
- Lifts
- Stairs
- Theatres
- Church
- Museum
- View Point
- Play Areas

Cathedral Bus Stops

- CB1 Rail Station
- CB2 Bus Station
- CB3 Milburngate
- CB4 Market Place
- CB5 Cathedral & Castle
- CB6 Car & Coach Park

Park & Ride Car Parks

- Sniperley — A9
- Belmont — D1
- Howlands — M6

Heritage

- 1 Durham Cathedral — G5
- 2 Durham Castle, Durham University — F5
- 3 Palace Green — G4
- 4 Town Hall — E5
- 5 World Heritage Site Visitor Centre — F4

Museums and Gardens

- 6 DLI Museum & Durham Art Gallery — B6
- 7 Durham Heritage Centre & Museum — G4
- 9 Botanic Garden, Durham University — M4
- 10 Wharton Park — C7
- 11 Crook Hall & Gardens — C4
- 12 Oriental Museum, Durham University — M6
- 13 Palace Green Library, Special Collections, Durham University — G5

Shopping

- 14 Prince Bishops Shopping Centre — F4
- 15 The Gates Shopping Centre — E5
- 16 Durham Indoor Market — E5
- 17 Fowlers Yard Creative Workspaces — F5

Culture

- 18 Gala Theatre & Cinema — E4
- 19 Assembly Rooms (Theatre) — G4
- 20 City Theatre — F5

Sport and Leisure

- 21 Freeman's Quay Leisure Centre — D4
- 22 Prince Bishop River Cruises (Summer) — F4
- 23 Rowing Boat Hire (April - October) — F4
- 24 Walkergate — E5

TOURS WITH TASTE

For a sumptuous visit why not begin or finish your tour with refreshments served in the medieval Prior's Hall, originally the Prior's Dining Room when the Cathedral was a monastery.
Minimum numbers of 15 apply.

- **Morning Coffee & Tour £7.25**
- **Cream Cake & Tour £10.00**
- **Lunch & Tour £12.50**
- **Afternoon Tea & Tour £11.25**
- **Evening Dinner & Tour £bespoke – optional attendance at the service of Evensong followed by an evening guided tour and fine dining**

All refreshments are provided by the Undercroft Restaurant, winner of a Taste Durham award. It provides a range of high quality dishes using local produce whenever possible. Groups can visit the restaurant itself with group members purchasing refreshments on an individual basis, but booking ahead into Prior's Hall is highly recommended. Bespoke menus for special occasions can be arranged to suit. All dietary requirements can be catered for.

DURHAM CATHEDRAL SHOP

The shop is located off the Cathedral Cloisters close to the Undercroft Restaurant. It is the perfect place to buy souvenirs offering a wide range of postcards, gifts, books and CDs.

PHOTOGRAPHY

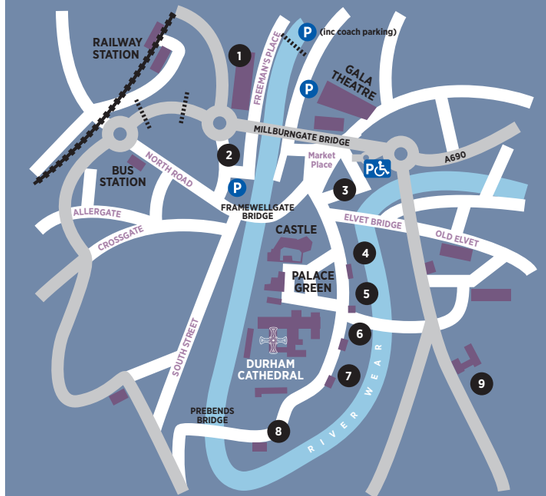
The Chapter does not permit photography within the Cathedral as it is a sacred place to which people come to pray and visit undisturbed. This includes the use of digital and video cameras and mobile phones. Photographs may be taken within the Precinct area including the Cloisters. There are many postcards and CDs of images available to purchase in the Gift Shop.

EXPERIENCES & PACKAGES

Durham Cathedral and St Chad's College
Residential packages available on selected dates. Guided tour of the Cathedral, optional attendance at the service of Evensong, refreshments and an evening Organ Recital.

Cathedral, Castle & World Heritage Site
Joint ticket for guided tour of the Cathedral, Castle and World Heritage Site on selected dates. Experience the magnificence one of Britain's first World Heritage Sites.

GETTING HERE



KEY
1 PASSPORT OFFICE
2 THE GATES DURHAM SHOPPING
3 PRINCE BISHOPS SHOPPING CENTRE
4 HATFIELD COLLEGE
5 DURHAM HERITAGE CENTRE
6 ST. CHAD'S COLLEGE
7 ST. JOHN'S COLLEGE
8 ST. CUTHBERT'S SOCIETY
9 JOB CENTRE

Transport
There is free coach parking at the City Centre Coach Park (the Sands). There is no parking at the Cathedral. Durham County Council provides a public shuttle bus service from the Coach Park and Durham Market Place to the Cathedral. An all-day ticket can be purchased on board. For timetable information please see www.durham.gov.uk/bustimetableinformation. The Sands Coach Park postcode is DH1 1SQ.

Access
Most of the Cathedral and Precinct is accessible; however as an historic building there are some uneven floors and certain areas are not accessible. For wheelchair users access is mostly via ramps; other services include accessible entrance, a stairclimber lift, large print guides, and an induction loop system. Wheelchairs are available on request. Assistance dogs welcome. If you have any access requirements or need any extra help or advice please do let us know in advance.

Further Information & Booking
Durham Cathedral wishes to provide a most enjoyable experience for all visitors, and understands that each group has its individual needs. To discuss your requirements further please contact our Group Travel Officer via
visits@durhamcathedral.co.uk
or **0191 374 4050**

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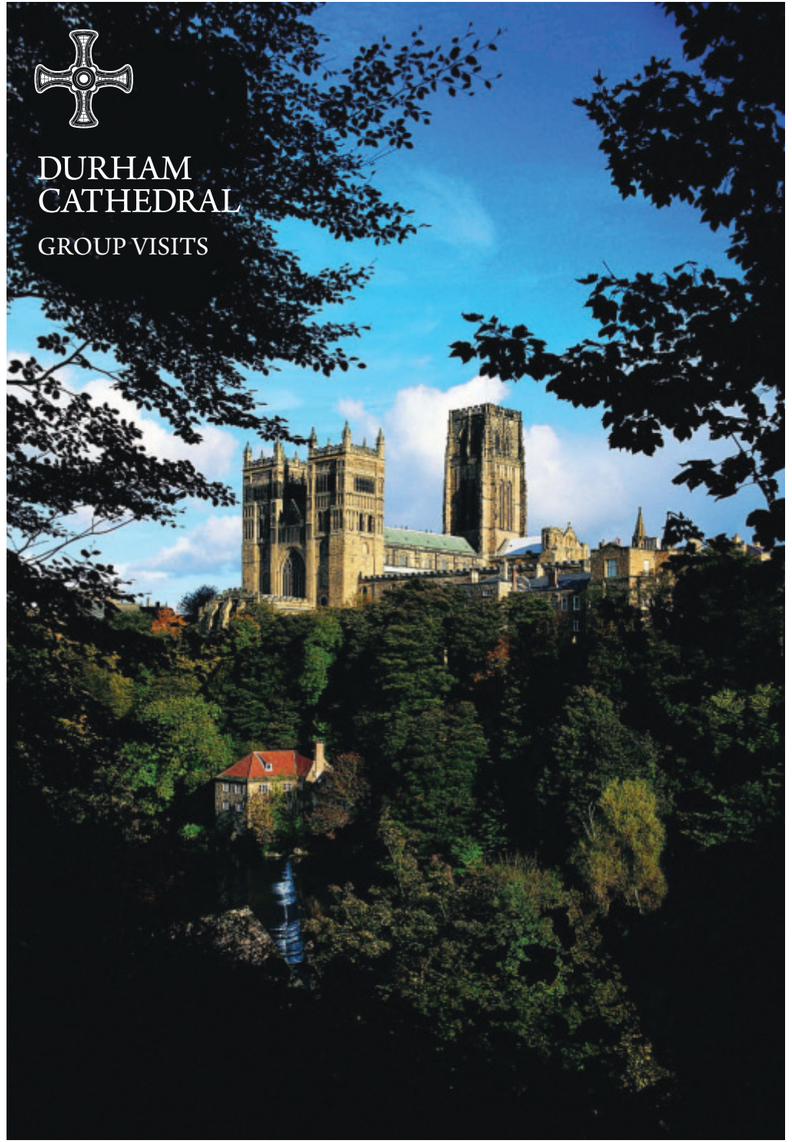
DURHAM CATHEDRAL

GROUP VISITS



Durham has been a place of prayer and pilgrimage for a more than a millennium; the stunning Norman Cathedral was built in 1093 to replace a Saxon monastic church. It houses the shrine of St Cuthbert, the 7th century Bishop of Lindisfarne; and the tomb of the Venerable Bede, who is often called the Father of English History, as author of the early 8th century The Ecclesiastical History of the English People.

The Cathedral is one of the finest examples of Norman architecture in Europe, or as American writer Bill Bryson says, "the best Cathedral on planet Earth". The stone vaulting in the Nave marks a turning point in the history of architecture, as pointed arches were used successfully for the first time instead of Romanesque semi-circular arches. This allowed the building to reach a greater height, paving the way for the Gothic style. Durham Cathedral forms part of a UNESCO World Heritage Site and is a living place for Christian worship. Visitors come from around the world.

Durham Cathedral is open to pre-booked groups on:
Monday – Saturday 9.30am – 5.00pm
Sunday 1.00pm – 3.00pm

Pre-booked groups of 12 or more people receive a range of exclusive benefits with a group rate of £5.00* per person that includes:

- Private group guided tour available in various languages
- Free place for the group organiser or tour manager
- Free self-guide leaflets for unguided tours in various languages
- Free familiarisation visit for organiser ahead of any visit
- Free coach parking at Durham City Centre Coach Park
- Refreshment voucher for the coach driver

Supplementary benefits can be booked subject to an additional charge:

- Special interest talks & behind the scene tours
- Refreshment packages

Evening group visits can also be arranged and can include private dining.

Durham Cathedral is a working Church, booking for groups is essential as special services or other events may be scheduled to take place on the day of your intended visit.

*2012 price per person for group visits

GUIDED TOURS

General Tour
Trained guides provide a tour which last approximately 1¼ hours. It includes the history and development of the Cathedral, the Shrine of St Cuthbert, the Tomb of the Venerable Bede, the Galilee Chapel, the Chapel of the Nine Altars, the Nave and the Quire.

Highlights Tour
For groups that only have a short time to view the Cathedral, a brief 30 minute tour outlines the Cathedral's main points of interest.

BEHIND THE SCENE TOURS & SPECIALIST TALKS

Exclusive behind the scene tours and talks on specialist subjects can be arranged. These may include entry into areas not open to the general public. To ensure availability please book as early as possible.

- Northern Saints
- Pilgrimage Tour
- Architecture
- Stained Glass Windows
- Embroidery & Textiles*
- Cathedral Library & Manuscript Treasures*
- Monastic (Rites of Durham)*
- History of Cathedral Music
- Decorative Art in the Cathedral
- The Art of the Woodcarver
- Other subjects may be available by request.

Durham Cathedral regularly hosts special events and Durham itself has a busy programme of cultural festivals. At the time of your enquiry do ask about upcoming events. There may be something of interest to your group.

*Additional charges apply to some specialist tours.

HOW TO PAY

Payment can be made on arrival at the Information Desk at the back of the Cathedral. It must be made in one payment for the whole group by cash, debit card, credit card or cheque (made payable to Durham Cathedral). Alternatively, by prior arrangement only, the Cathedral can issue an invoice. Minimum numbers apply and will be charged for group bookings.

OPEN TREASURE

Durham Cathedral is reorganising its exhibition space as part of a project called Open Treasure. When complete the Cathedral will be able to display more of its internationally important collections in new exhibition space in some of the Claustral buildings (located off the Cathedral Cloisters). During 2012 the shop will move from the Great Kitchen to the Undercroft. Stunning exhibition space will be developed in the Great Kitchen and in the Monks' Dormitory, linked via a new glazed walkway and gallery. This work should be complete during 2013. At present the Treasures of St Cuthbert are not on display. The relics themselves are in suitable storage ahead of conservation work before they are returned to public view. Some elements of the Cathedral's collections can be seen as part of the specialist talks available to groups listed on this page, in particular the Cathedral Library & Manuscript Treasures talk.

LONDON MATHEMATICAL SOCIETY - DURHAM SYMPOSIUM

Day Trip Information

WHITBY & ROBIN HOOD'S BAY

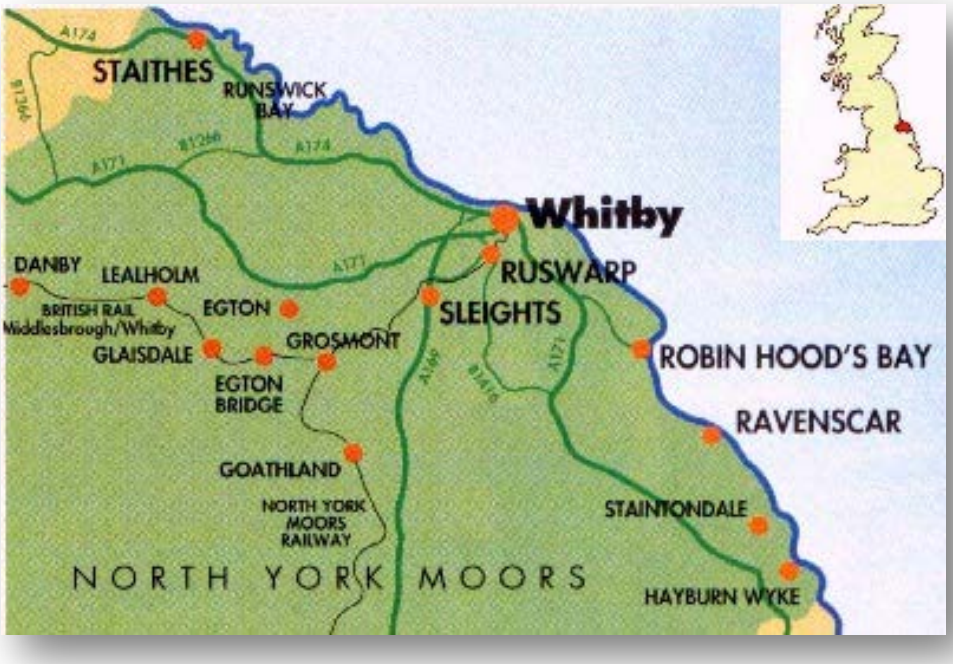
LMS EPSRC DURHAM SYMPOSIUM

WHITBY & ROBIN HOOD'S BAY

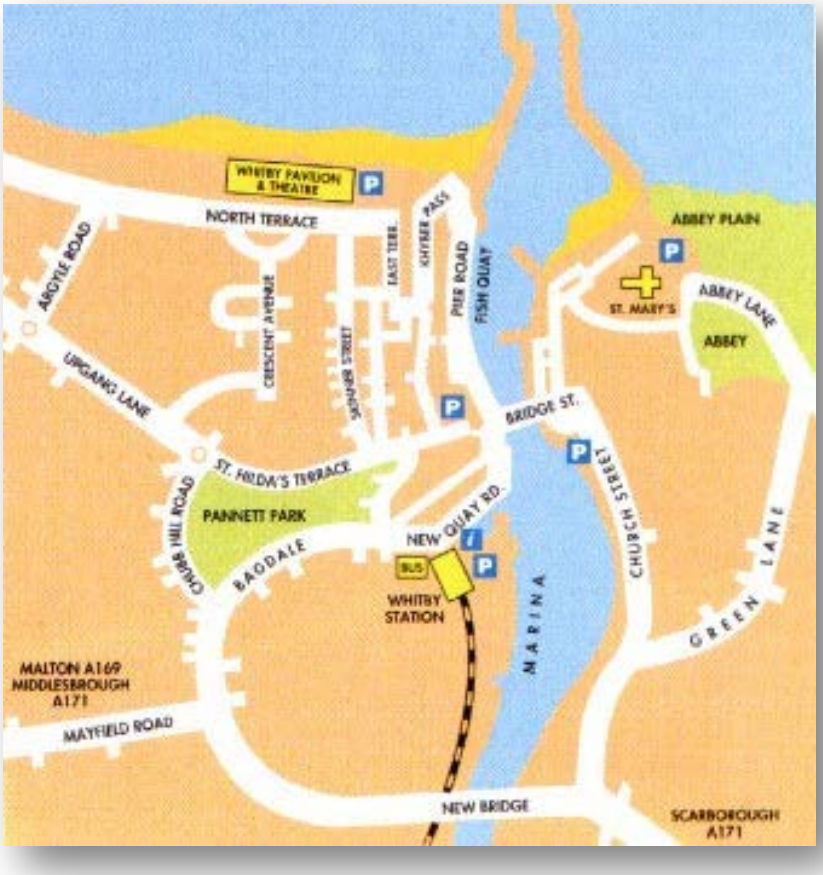
- Bus leaves Grey College, Main Entrance at 9.15 am
- Arrive Robin Hood's Bay at approximately 11.00 am
- Less active members of party explore RHB (period of 1 hour) then continue by coach to Whitby
- Active members walk about 12km along the coast path to Whitby. Stop for lunch at about 1.00 pm arrive Whitby about 2.15 pm
- Rendezvous at bus pick up point on Langbourne Road off New Quay Road past Tourist Information and the co-op opposite the Harbour Office on the river coach park for 4.00 pm departure
- Arrival at Grey for approximately 5.30 pm

Please note all times are approximate.

The North Yorkshire Coast



Whitby



ROBIN HOOD'S BAY

Robin Hood's Bay is a scenic fishing village in North Yorkshire. The origins of the name are unknown but there are many speculations. The name does not appear in any records until the sixteenth century, although it is sometimes known as 'Baytown'. A mile to the south of the village are bronze age burial mounds called 'Robin Hood's Butts'. The village road runs steeply down to the very edge of the rocky shore and there are intriguing alleyways weaving between tightly-packed cottages and houses.

Robin's Hood Bay has operated as a village under various aliases. Nothing exists in fact to determine where its name really came from. Once known as Bay Town, Robin Hood's Town and Robbyn Huddes Bay-whatever it is called-it is still a charming spot, with every twist and turn of a street bringing into view another picture postcard scene. Red pantiles decorate the roofs of stone cottages. A stream runs through a ravine in the middle of the village to the sea below. Shops, cafes, pubs and small cottages cling precariously to the sides of the cliff. The Laurel Inn has a bar carved from solid rock.

Viking raiders settled here. Fifty fishermen lived here in 1536, and the catching and drying of fish was a thriving industry-130 fishermen worked here until the end of the 19th century. Tourist trade soon took the place of the fishing trade as the development of railroads brought people to this area. Nobody knows how many smugglers plied their illicit trade at Robin Hood's Bay.

This former smugglers' den owes its reputation to its strategic position sitting below a steep cliff lapped by the sea. It was ideal for such nefarious activities. And its rabbit warren of narrow tumbled streets and alleyways made it ideal for escaping the law. Legend has it that secret tunnels and passageways once existed between the houses. Perhaps they still do.

At low tide, 1800 feet (550m) of exposed sea floor make for great fossil hunting, tide pool investigation and exploring. At high tide, the sea has been known to force its way up the main village street, which ends in the sea, where the ocean literally laps at your feet. This charming village takes on a different demeanor when fog and storm and high winds abound, and seas pound the cliffsides. The raging storms have taken their toll, claiming many buildings as the limestone cliffs erode. In 1780, 22 cottages fell into the sea. Today a rock seawall helps protect the picturesque village.

Robin Hood's Bay with its labyrinth of streets and cottages piled on top of one another, clinging like wild goats to the cliffside, paints a vivid picture that stays long in one's memory.

Please see www.britainexpress.com and www.robin-hoods-bay.co.uk for further information.

WHITBY

The town lies in North Yorkshire on the mouth of the river Esk. The river flows through a narrow gully to reach the sea. On the cliffs above are the ruins of Whitby Abbey founded by St. Hilda in AD 658. The famous Synod of Whitby was held here in AD 664. The first recorded Saxon poet, Caedmon, lived and worked there.

Whitby has long had a reputation among mariners as a safe harbour and the main refuge between the Humber and the Tyne. By the 18th century the port was substantial. There were three roperies, several large ship-building yards, and even a dry-dock.

Whitby is dominated by the cliff-top ruins of a beautiful 13th century Abbey. This quaint maritime town, with its old cobbled streets, picturesque houses and sandy blue flag beach, is set among fine stretches of coast with spectacular cliffs and bays. 199 steps lead down from the Abbey to the old town where you find yourself in a shoppers' paradise. With an array of unique shops offering local crafts, famous Whitby Jet jewellery, maritime memorabilia and antiques, you are sure to find that holiday treasure.

A selection of diverse attractions includes the Captain Cook Memorial Museum, Victorian Jet Works, the Dracula Experience and Whitby Museum, which offers a cabinet of curiosities from geology to jet carving, birdlife to bygones and costumes to clocks.

Attractions

Captain Cook Memorial Museum

The Museum is in the 17th century house on Whitby's harbour where the young James Cook lodged as apprentice. It was here Captain Cook trained as a seaman, leading to his epic voyages of discovery.

Whitby Jet Heritage Centre Victorian Jetworks

Whitby Jet was undoubtedly one of the earliest gemstones used to create artefacts and items of jewellery and has a cultural heritage that extends back to early tool making man. It is the fossilized remains of a tree from the Jurassic period and is only found along a seven and a half mile stretch of the North Yorkshire coastline centred around Whitby.

The Whitby Jet Heritage Centre is located at the end of Church Street, one of Whiby's oldest, and still cobbled, streets. Church Street boasts a variety of shops, galleries, pubs and restaurants, and terminates at the foot of the famous 199 steps which lead up to Whitby Abbey.

Whitby Abbey

The abbey was founded in 657 AD and under the charge of St Hilda it hosted the Synod of Whitby in 664 when it was decided to uphold the Roman rather than Celtic Christian customs of worship thus profoundly influencing British political and religious history ever since. The abbey has been destroyed and rebuilt on a number of occasions and the present ruins date from the Benedictine Abbey of 1220.

St Mary's Church

At the top of the 199 steps is St Mary's church and the churchyard in which the ill fated Lucy and her friend Mina from Bram Stoker's gothic novel *Dracula* would sit looking over the harbour and talking to Mr Swales.

Whitby Museum

The Whitby Literary & Philosophical Society was established in 1823 and has around 800 members. It is one of the very few remaining Literary & Philosophical Societies that still runs an independent Museum, the older parts of which are often regarded as a 'Museum within a M useum' and have the atmosphere of an Edwardian Museum. The extension, opened in 2005, of fers a costume gallery, temporary exhibition, lecture (Normanby) room and tearoom facilities.

Please see the following websites for further information:

www.whitbytourism.com
www.cookmuseumwhitby.co.uk
www.whitbyjet.net
www.whitbymuseum.org.uk

Whitby Street Map