**First Order Predicate Calculus (FOPC)**   
**First Order Logic (FOL)**   
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Aristotle (384-322 BC): generalizations over objects. (click [***here***](http://www.utm.edu/research/iep/a/aristotl.htm), [***here***](http://www-gap.dcs.st-and.ac.uk/%7Ehistory/Mathematicians/Aristotle.html) and [***here***](http://www.ucmp.berkeley.edu/history/aristotle.html) for links to info on Aristotle)

De Morgan (1860s) (click [***here***](http://www-gap.dcs.st-and.ac.uk/%7Ehistory/Mathematicians/De_Morgan.html) for info on Augustus De Morgan)

First formal treatment:

G. Fregge (1879s) - Begriffscgrift (Concept Writing, Conceptual Notation) (click [***here***](http://mally.stanford.edu/frege.html)  for info on Fregge)

[***C. S. Peirce***](http://www.peirce.org/) (1883):  Independently of Fregge (possibly the greatest American philosophers/mathematicians)

Limitations of the propositional language/logic:

* The world consists of facts.
* Arguments under consideration are those expressed in terms of relations between propositions:
  + simple and compound propositions.
* No means to investigate inside simple propositions.

Yet, in natural language we can grasp the idea that seemingly different arguments are actually identical:

Example:

|  |  |
| --- | --- |
| All men are mortal.  John is a man. | All students are young.  Toru is a student. |
| Therefore, John is mortal. | Therefore, Toru is young. |

The **form/pattern of the argument is the same** in each of the above arguments, even though one refers to men and their property of being mortal and the other refers to students and their property of being young.

Moreover, another limitation of propositional logic is the inability to produce inference that can capture the following natural language reasoning:

***Horses are animals. Therefore, the head of a horse is the head of an animal.***   
(This example was given by Augustus De Morgan, who gave the first treatment of logic relation of predicates with many arguments, to point the limitations of Aristotle's logic - syllogisms)

Need to develop a different notation for representing the internal form of propositions.   
In this notation sentences will no longer be represented by simple symbols: **p, q, r,..**.

To understand what is required of the new notation, consider the following examples:

*Mike is happy.*   
*Yuki is a loser.*   
*Everest is high.*

Each of these statements is constructed from two parts:

* **The referring part:** the part that **picks an object** - a person or a thing - that is talked about;
* **The predicating part: something is stated** about the thing picked (referred to).

**objects** : What can be referred to; it makes sense to count them.

How referring can be done:

* **Proper names**: Bill, Toru, John - a proper name always denotes the same object (it may not mean anything real - e.g. Pegasus the flying horse)
* **Singular personal pronouns**: I, you, he.
* **Demonstratives**: this, that, etc.
* **Definite descriptions:** Ann’s book

Conventions for denoting objects (in FOL) in the textbook (Often, by analogy with programming languages, these conventions may be reversed):

* **upper case letters**, strings represent object **constants**.
* **lower case letters** represent object **variables**.

**What is a predicate?**

A **predicate** is used to express:

* a **property** which is ascribed to **one object** when a sentence is formed by completing the property with the name for the object.
  + **\_is happy, \_is a loser, \_ is high** denote predicates (properties).  More generally, using object variables we write **X is a loser**.
* a **relation between objects** when a sentence is formed by completing the names of the relation with the names of the objects.
  + Toru **loves** Yuki: **\_ loves \_**expresses a relation with two arguments. More generally, using object variables we write, **X loves Y**.
  + Fagaras **is between** Brasov and Sibiu : **\_  is between \_ and \_** expresses a relation with more than two arguments. More general, using object variables, we write **X is between Y and Z.**

Predicate symbols: convention by which a predicate symbol refers to a particular relation: **is\_a\_loser** (or just **loser**), **is\_happy** (or just **happy**), **loves**, **between.**

Often we will use the generic predicate symbols **pred, pred1, pred2**, etc.

**Predicates can be defined in two ways**:

* rules relating them to other previously defined relations
* enumeration of the tuples (ordered sets) of objects which make up their arguments

**Functions:**  relations are functional - one-to-one relation: one object is related to exactly one other object by the relation.

Example: **X  is\_mother\_of Y**: given Y there is only one X such that the relation is\_mother\_of holds.

Notation:  X = **is\_mother\_of(Y)**.

Any function (with n arguments) can be turned into a relation with n+1 arguments:

Example: **is\_mother\_of(X,Y)**

The converse is not always true.

**Predicates versus functions**:

* with predicates we need symbols for all objects involved.
* with functions we need not: the function **is\_mother\_of(Y)** returns the object corresponding to the symbols X when the predicate, rather than the function is used.

**Quantifiers**:  indicate the extent (number of objects) in the domain over which a predicate applies.

In language:   **all, some, one** (and only one, exactly one), **at least one, exactly 3, exactly k, most, many, a few, several**.

**General (more formal definition of a quantifier)**:

Given a collection of objects O, a quantifier Q represents the collection of all subsets of O with Q objects.  O is also called **domain of quantification**.

Therefore, **all students at UC**   
O = {x; x is a UC student (according to some definition)}   
|O| = cardinality of O (number of elements in it).

**all** = { S; S subset of O such that |S| = all = |O|} = O   
**exactly k** = {S; S subset of O such that |S| = k <= |O|}   
**exactly three** students in this class are awake during lectures   
Note that quantifiers such as most, a few cannot be represented as above since the concepts are vague.

In logic (mathematics) we use:   
the **universal quantifier**:  all (for all, everyone) **∀**   
the **existential quantifier**: there exists (some, at least one) **∃**

We will translate using quantifiers as follows:

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| --- | --- |
| **natural language sentence** | **quantified formula (using ∀ or ∃ )** |
| Everyone is happy | ∀x happy(x) |
| Everybody  loves Lucy | ∀x love(x, Lucy) |
| Some people do not like Lucy | ∃x people(x) **∧**   ~like(x, Lucy) |
| All men are mortal | ∀x man(x) → mortal(x) |
| Tipu lost a battle | ∃x battle(x) ∧ lost(Tipu, x) |
| John hates something(s) | ∃x hates(John, x) |

**Note:**   
In translating compound sentences we will use → with ∀ and ∧ with **∃**

Nested quantifiers:

When using more than one object variable, more than one quantifier must be used: **well formed formula** - every object variable is introduced by a quantifier.

Simple cases: same quantifier for all object variables appear in the predicates used:

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| **natural language sentence** | **quantified formula (using ∀ or ∃)** |
| For all x and y , if x is the mother of y, y is the offspring of x | **∀x, ∀y,mother(x,y) → offspring(y, x)**  (we can drop one **∀** without introducing any ambiguity)  **∀x, y mother(x,y) → offspring(y, x)** |

More complex cases: different quantifiers

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| --- | --- |
| **natural language sentence** | **quantified formula (using ∀ or ∃)** |
| Someone is loved by everyone | ∃ x, ∀y loves(y, x) |
| There exists a woman whom all men love | ∃ x,∀y woman(x) ∧ (man(y) → loves(y, x)) |
| There is a woman who likes all men | **∃**x, ∀y  woman(x)∧man(y) → loves(x,y) |

Relation between ∀ and∃

* **∀**is a conjunction over the universe of objects
* **∃**is a disjunction over the universe of objects

Therefore the De Morgan laws apply:

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| **De Morgan laws for proportional logic** | **De Morgan laws for FOL (with quantifiers)** | **Language equivalent** |
| **~( p∨q) = ~p ∧ ~ q** | ~∃x p(x) = ∀x ~p(x) | there is no x p(x)   same as  for all x not p(x) |
| **~( p ∧ q) = ~p ∨ ~ q** | ~ ∀x p(x) =∃x ~p(x) | Not all x p(x)   same as  there is x such that not p(x) |
| ~( p ∨ q) = ~p ∧ ~ q | ~∃x p(x) = ∀x ~p(x) | there is no x such that p(x) same as  for all x ~p(x) |
| ~(~p ∧ ~q) = p ∨ q | ~ ∀x ~p(x) =∃x p(x) | not true that for all  x not p(x)   same as  there exits x p(x) |
| ~( ~p ∨ ~q) = p ∧ q | ~∃x ~p(x) = ∀x p(x) | there is no x such that not p(x)  same as  for all x p(x) |

**Equality:** Another way, besides predicates and quantifiers, of making (atomic) sentences.

From the beginning the status of the equality was (and remains) controversial (what is the meaning of = in a=a, and a=b, identity relation or comparison operator?)

From a practical stand point we may need the equality in order to be able to represent more efficiently certain type of knowledge, for example to express that two terms are not the same object.

"*Ann has at least two sisters*"   : ∃ x, y sister(Ann,x) ∧ sister(Ann,y) ∧ ~(x = y)   
"Ann has exactly two sisters" :∃ x, y  sister(Ann,x) ∧ sister(Ann,y) ∧ ~(x = y) **∧∀z ( ~(z=x)∧ ~(z = y) → ~sister(Ann,z))**

**The text above highlighted in blue states, that any z which not equal to x or y is NOT a sister of Ann. We could have written instead**

**∀z (sister(Ann, z) → (z=x) ∨ (z = y))**

Note though, how much more cumbersome (although, at first glance, straightforward) is to express "at least 10": **it would be the collection of all subsets with cardinality less than or equal to 10**.

**Uniqueness quantifier** ∃!can be used as a shortcut for some instances of "exactly"   
 example:   
"there is but one king (there exists exactly one king)" : ∃! x king(x)   
How can∃! be expressed in terms of∃ and equality?

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| **BNF Grammar for the first-order predicate logic** |
| **Sentence :=  AtomicSentence**  **|  Sentence  Connective  Sentence**  **|  Quantifier Variable, .... Sentence**  **| ~ Sentence**  **| (Sentence)** |
| **AtomicSentence   :=  Predicate(term,...)**  **| Term = Term** |
| **Term  := Function(Term,...)**  **| Constant**  **| Variable** |
| **Connective :=  →   | ∧  | v    | 🡨🡪** |
| **Quantifier  := ∀ |** ∃ |
| **Constant  := A | X1 | John | ...** |
| **Variable  := a |  x  |  s** |
| **Predicate := between | before | raining | ...** |
| **Function  := mother\_of | right\_hand\_of | ...** |

In Prolog, the convention is reversed: variables start with capital letters (in standard Prolog), or least the first two capitals in Prolog, and constants start with lower case letters.

**Recall**: the order of precedence for connectives (from highest to lowest):  ~, ∧,**∨**, 🡪, 🡨🡪

For example, in propositional logic,

p ∧ q → r is the same as  (p∧q) → r.

 p ∨ ~q ∧ r → s  <→ t  is the same as ( p ∨ ((~q)∧r)   ) 🡨🡪 t   
 

**Axioms, Definitions, Theorems**

**axiom:** basic fact about a domain (needs no proof).   
**definition**: introduction of concepts described in terms of basic facts.   
**theorems:** facts about a domain deduced from axioms and known concepts.

Question: when/how a domain is fully specified?  Size of the axiom set.

**Independent axioms**: cannot be derived from other axioms.

**Example**: the Euclidean geometry

**Axioms**   
1. It is possible to draw one and only one straight line from any point to any point.

2. From each end of a finite straight line it is possible to produce it continuously in a   straight line by an amount greater than any assigned length.

3. It is possible to describe one and only one circle with any center and radius.

4. All right angles are equal to one another.

5. (Euclid's fifth axiom). Through a given point not on a given straight line, and not on that straight line produced, no more than one parallel straight line can be drawn.

Note: Non-Euclidean geometries reject axiom 5. (e.g. Bolyai-Lobacevski)

**Theorems**

  1. A straight line falling on parallel straight lines makes the alternate angles equal to one another, the exterior angle equal to the interior and opposite angle, and the interior angles on the same side equal to two right angles.

 2. Straight lines parallel to the same straight line are also parallel to one another.

3. In any triangle, if one of the sides be produced. The exterior angle is equal to the two interior and opposite angles, and the three interior angles of the triangle are equal to two right angles.

4. In any parallelogram the opposite sides and angles are equal to one another, and the diagonal bisects the area.

5. Parallelograms, which are on the same base and in the same parallels, are equal to one another.

6. Triangles, which are on the same base and in the same parallels, are equal to one another.

7. If a parallelogram has the same base as a triangle and is in the same parallels, the parallelogram is double the   triangle.

8. On a given straight line it is possible to describe a square.

9. (Pythagorean theorem). In right-angled triangles the square on the side subtending the right angle is equal to the squares on the sides containing the right angle.   
 

**Mathematics versus AI**

KB : collection of axioms (facts) and eventually definitions   
In mathematics one looks for a **minimal set of axioms**.  In AI the KB may contain **redundant axioms** to improve efficiency.

**USING FIRST-ORDER LOGIC**

**family relations domain**: binary relations describing the family relations: parent, sibling, brother, sister, wife, husband, etc.

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| **natural language description** | **FOL  definition** | **Prolog** |
| someone's mother is that person's female parent | ∀c, mother(c) = m 🡨🡪 female(m) ∧ parent(m,c) | mother(M, C)  :-           female(M),             parent(M, C). |
| someone's husband is that person's male spouse | ∀p, husband(p)=h   🡨🡪 male(h) ∧ spouse(h,p) | husband(P, H) :-              male(H),               spouse(H, P). |
| someone is a male if and only if that person is not female (male and female are disjoint categories) | ∀p male(p) 🡨🡪 ~female(p) | male(P) :-                \female(P).  or  male(P) :- female(P), !, fail.  male(\_). |
| someone is someone else's parent if the latter is the  former's child (parent and child are inverse relations) | ∀p, c   parent(p, c) 🡨🡪 child(c, p) | parent(P, C) :-                   child( C, P). |
| a grandparent is the parent of someone's parent | ∀g, c grandparent(g, c)   🡨🡪  ∃p parent(g, p) ∧ parent(p, c) | grandparent(G, C) :-           parent(G, P),            parent(P, C). |
| a sibling is another child of someone's parent | ∀x,y sibling(x, y)  🡨🡪  ~(x=y) ∧∃ p parent(p,x) ∧ parent(p, y) | sibling(X, X) :- !, fail. sibling(X, Y):-         parent(P, X),            parent P Y). |

**The domain of sets:**

The empty set is a constant (we can call it emptySet or phi)   
member, subset, intersection, union, adjoin (adding one element to an existing set) are predicates   
set is a one place predicate which holds true only for sets.

Axioms for the domain of sets:

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| --- | --- | --- |
| **natural language description** | **FOL definition** | **Prolog** |
| A set is the empty set or the set obtained by adjoining something to a set | ∀ s  set(s)   🡨🡪   (s=phi ) v   ∃ x, s1 set(s1) ∧ s = adjoin(x,s1) | **set([]).** **set(S)** :-  **set(S1),**   **adjoin( X, S1, S).** |
| The empty set has no element adjoined into it | ~**∃**x, s adjoin(x, s) = phi |  |
| Adjoining an element already in the set has no effect (a set has only distinct elements) | ∀x, s   member(x,s) 🡨🡪 adjoin(x,s)=s | **adjoin(X, S, S) :-**  **member(X, S)**  *note: this is only part of the definition of adjoin* (think of how to complete it by adding another clause) |
| The only members of a set are those that were adjoined to it | ∀x, s1 member(x, s1) 🡨🡪∃ y, s2 adjoin (s1 = adjoin(y,s2) ∧ (x = y ∨ member(x, s2)) | *note: the disjunction in the FOL description results in two Prolog clauses* |
| A set is a subset of another set if all the elements of the former belong to the latter | ∀ s1, s2   subset(s1, s2)   🡨🡪 (∀x member (x,s1) → member (x, s2)) | **subset([H1|T1], S2) :-**  **mem(H1, S2, S21),**  **subset( T1, S21).**  *Remarks:*  *1.* mem *is a version of member predicate which removes an element from the list once it has been tested/found to be in the list.*  Define mem…  *2. Nothing is said about the empty set. To make this operational we would need such a definition (added at the top of the definition for subset, i.e. preceding the previous clause for subset):*  **subset([], S).** |
| Two sets are equal if and only if each is a subset of the other | ∀s1, s2   (s1 = s2)   🡨🡪   subset(s1, s2) ∧ subset(s2, s1) | *Usually we will not need to define equality because it follows from the pattern matching mechanism of the language.  But, if we still want to do it:*  **equalSets(S, S).**  **equalSets(S1, S2) :-**  **subset(S1, S2),**  **subset(S2, S1).** |
| The intersection of two sets consists of their common elements | ∀x, s1, s2 member (x, intersection(s1, s2)) 🡨🡪  member(x, s1) ∧ member(x, s2)) | **intersection( [], S, []).** **intersection( [H1 |T1], S2, [H1|T]):-**  **member(H1, S2),**  **intersection(T1 S2 T).**  ***check !!!*** |
| The union of two sets consists of all the elements which are in either of the to sets | ∀x, s1, s2  member(x, union(s1, s2))   🡨🡪  member(x, s1) ∨ member(x,s2)) | **union([], T, T).**  **union( [H1 |T1], S2, [H1|T]):-**  **(union T1 S2 T)).**  **union([H1|T]) :-**  **union(T1, S2, T).**  ***(must check for correctness!!!)*** |

**Exercises:**

1. Represent the following sentences in first- logic using a consistent vocabulary (which you must define) and then in Prolog (with appropriate comments to indicate difficulties, etc.):

* Not all students take both History and Biology

**~ ∀ x student(x) → take(x, History) ∧ take(x, Biology)**

* Only one student failed History

**∃ x student(x) ∧ failed(x, History) ∧ ∀ y student(y) ∧ failed(y, History)  → x=y**

* Only two students failed both History and Biology.

**∃ x ∃ y  failed(x, History) ∧  failed(x, Biology) ∧  failed(y, History) ∧ failed(y, Biology) ∧~ (x=y) ∧ ∀ z failed(z, History) ∧ failed(z, Biology) → (z=x) ∨ (z=y)**

* The best score in History was better than the best score in Biology.

**∃ x score(x, History) ∧ (x=BestScoreH) ∧ ∃ y score(y, History) ∧ (y=BestScoreH) ∧  better(x, y)**

* Every person who dislikes all vegetarians is smart.

**∀ x ∀ y person(x) ∧ vegetarian(y) ∧ dislikes(x,y) → smart(x)**

* No person likes a smart vegetarian.

**~****(∀ x ∃ y vegetarian(y) ∧ smart(y) ∧ p(x) → likes (x,y) )**

this can also be rewritten as

**∃ x p(x) ∀ y vegetarian(y) ∧ smart(y) ∧ p(x) ∧~likes(x,y)**

* There is a woman who likes all men who are not vegetarian.

**∃ x woman(x) ∧ predicate(x)**

where ***predicate(x)***stands for ***"likes all men who..."*** therefore we can write it

**∀ y men(y) ∧ ~ vegetarian(y) ∧ likes(x,y)**

and hence the final formula is

**∃ x woman(x) ∧ ∀ y men(y) ∧ ~vegetarian(y) ∧ likes(x,y)*.***

* There is a barber who shaves all men in town who do not shave themselves.

**∃ x barber(x) ∧ ∀ y, man(y) ∧ intown(y) ∧~shaves(y, y) ∧ shaves(x, y)**

* No person likes a professor unless the professor is smart.
* Politicians can fool some of the people all of the time, and they can fool all the people sometimes, but they cannot fool all the people all of the time.

2. Consider the predicates *Speaks(x, l)* to mean *"x speaks language l"*.  Represent the sentence *"All Germans speak the same language"* in predicate logic.  Translate this in Prolog clauses.

**∃ l, language(l) ∧ ∀ x, german(x)  → speaks(x,l)**

Prolog clauses

**speaks(X, language) :- german( X).**

3. Write down FOL definitions and Prolog for the following family relations predicates: Grandchild,  GreatGrandChild, Brother, Sister, Daughter, Son, Aunt, Uncle, BrotherInLaw, SisterInLaw, FirstCousin.  Use these predicates to encode the following knowledge base and make all possible inferences from it:

*George was married to Mum and had two children, Elizabeth and Margaret. Spencer was married to Kydd and one daughter, Diana who was married to Charles and had two sons, William and Harry.  Charles's parents were Elizabeth and Philip who are married to each other and had, in addition to Charles, two other sons, Andrew and Edward and a daughter Ann.  Ann married Mark by which she had two children, Zara a daughter and a son, Peter.  Andrew married Sarah and had two daughters, Beatrice and Eugene, while Edward married Sophie and has no children.*

Solution: easy but time consuming

* 1. The following text is a small part of the US Laws on Immigration and Nationality, related to asylum status.  Define an appropriate dictionary of terms, and translate it in FOL and then in Prolog clauses only the paragraphs printed in bold letters:

*US Code as of: 01/02/01*

*Sec. 1158. Asylum*

***(a) Authority to apply for asylum***   
***(1) In general***   
***Any alien who is physically present in the United States or who***   
***arrives in the United States (whether or not at a designated port***   
***of arrival and including an alien who is brought to the United***   
***States after having been interdicted in international or United***   
***States waters), irrespective of such alien's status, may apply***   
***for asylum in accordance with this section or, where applicable,***   
***section 1225(b) of this title.***   
*(2) Exceptions*   
*(A) Safe third country*   
*Paragraph (1) shall not apply to an alien if the Attorney*   
*General determines that the alien may be removed, pursuant to a*   
*bilateral or multilateral agreement, to a country (other than*   
*the country of the alien's nationality or, in the case of an*   
*alien having no nationality, the country of the alien's last*   
*habitual residence) in which the alien's life or freedom would*   
*not be threatened on account of race, religion, nationality,*   
*membership in a particular social group, or political opinion,*   
*and where the alien would have access to a full and fair*   
*procedure for determining a claim to asylum or equivalent*   
*temporary protection, unless the Attorney General finds that it*   
*is in the public interest for the alien to receive asylum in*   
*the United States.*   
*(B) Time limit*   
*Subject to subparagraph (D), paragraph (1) shall not apply to*   
*an alien unless the alien demonstrates by clear and convincing*   
*evidence that the application has been filed within 1 year*   
*after the date of the alien's arrival in the United States.*   
*(C) Previous asylum applications*   
*Subject to subparagraph (D), paragraph (1) shall not apply to*   
*an alien if the alien has previously applied for asylum and had*   
*such application denied.*   
*(D) Changed circumstances*   
*An application for asylum of an alien may be considered,*   
*notwithstanding subparagraphs (B) and (C), if the alien*   
*demonstrates to the satisfaction of the Attorney General either*   
*the existence of changed circumstances which materially affect*   
*the applicant's eligibility for asylum or extraordinary*   
*circumstances relating to the delay in filing an application*   
*within the period specified in subparagraph (B).*   
*(3) Limitation on judicial review*   
*No court shall have jurisdiction to review any determination of*   
*the Attorney General under paragraph (2).*

***(b) Conditions for granting asylum***   
***(1) In general***   
***The Attorney General may grant asylum to an alien who has***   
***applied for asylum in accordance with the requirements and***   
***procedures established by the Attorney General under this***   
***section  if the Attorney General determines that such alien is a***   
***refugee  within the meaning of section 1101(a)(42)(A) of this title.***   
*(2) Exceptions*   
*(A) In general*   
*Paragraph (1) shall not apply to an alien if the Attorney*   
*General determines that -*   
*(i) the alien ordered, incited, assisted, or otherwise*   
*participated in the persecution of any person on account of*   
*race, religion, nationality, membership in a particular*   
*social group, or political opinion;*   
*(ii) the alien, having been convicted by a final judgment*   
*of a particularly serious crime, constitutes a danger to the*   
*community of the United States;*   
*(iii) there are serious reasons for believing that the*   
*alien has committed a serious nonpolitical crime outside the*   
*United States prior to the arrival of the alien in the United*   
*States;*   
*(iv) there are reasonable grounds for regarding the alien*   
*as a danger to the security of the United States;*   
*(v) the alien is inadmissible under subclause (I), (II),*   
*() the alien is inadmissible under subclause (I), (II),*   
*removable under section 1227(a)(4)(B) of this title (relating*   
*to terrorist activity), unless, in the case only of an alien*   
*inadmissible under subclause (IV) of section 1182(a)(3)(B)(i)*   
*of this title, the Attorney General determines, in the*   
*Attorney General's discretion, that there are not reasonable*   
*grounds for regarding the alien as a danger to the security*   
*of the United States; or*   
*(vi) the alien was firmly resettled in another country*   
*prior to arriving in the United States.*   
*(B) Special rules*   
*(i) Conviction of aggravated felony*   
*For purposes of clause (ii) of subparagraph (A), an alien*   
*who has been convicted of an aggravated felony shall be*   
*considered to have been convicted of a particularly serious*   
*crime.*   
*(ii) Offenses*   
*The Attorney General may designate by regulation offenses*   
*that will be considered to be a crime described in clause*   
*(ii) or (iii) of subparagraph (A).*   
*(C) Additional limitations*   
*The Attorney General may by regulation establish additional*   
*limitations and conditions, consistent with this section, under*   
*which an alien shall be ineligible for asylum under paragraph*   
*(1).*   
*(D) No judicial review*   
*There shall be no judicial review of a determination of the*   
*Attorney General under subparagraph (A)(v).*   
*(3) Treatment of spouse and children*   
*A spouse or child (as defined in section 1101(b)(1)(A), (B),*   
*under this subsection may, if not otherwise eligible for asylum*   
*under this section, be granted the same status as the alien if*   
*accompanying, or following to join, such alien.*   
    
    
 