Learn Python with Django

Designing the Library models

Django web applications access and manage data through Python objects referred to as models. Models define the *structure* of stored data, including the field *types* and possibly also their maximum size, default values, selection list options, help text for documentation, label text for forms, etc. The definition of the model is independent of the underlying database — you can choose one of several as part of your project settings.

Before you jump in and start coding the models, it's worth taking a few minutes to think about what data we need to store and the relationships between the different objects.

We know that we need to store information about books (title, summary, author, written language, category, ISBN) and that we might have multiple copies available (with globally unique id, availability status, etc.). We might need to store more information about the author than just their name, and there might be multiple authors with the same or similar names. We want to be able to sort information based on book title, author, written language, and category.

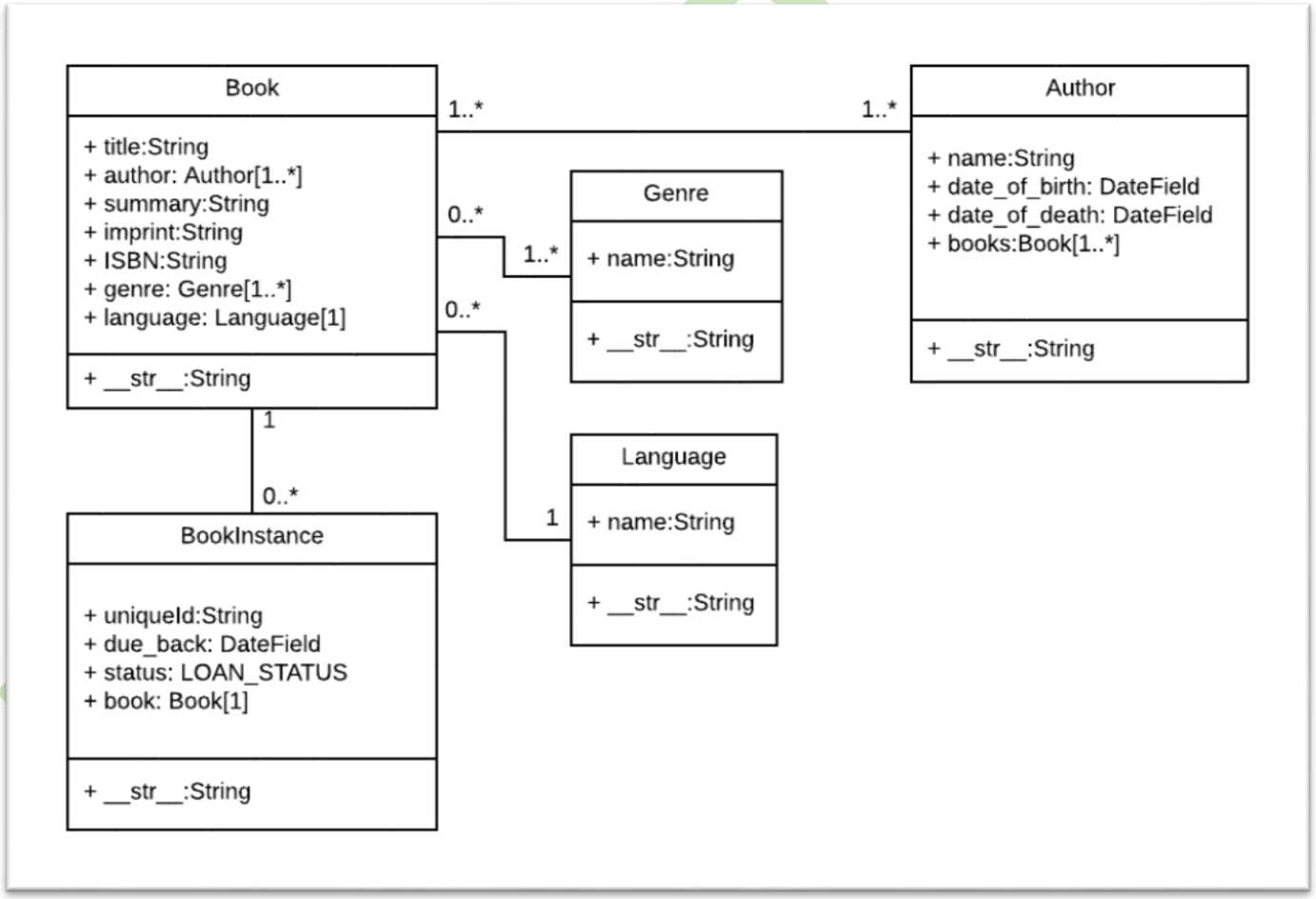
When designing your models it makes sense to have separate models for every "object" (group of related information). In this case the obvious objects are books, book instances and authors.

You might also want to use models to represent selection-list options (e.g. like a drop down list of choices), rather than hard coding the choices into the website itself — this is recommended when all the options aren't known up front or may change. Obvious candidates for models in this case include the book genre (e.g. Science Fiction, French Poetry, etc.) and language (English, French, Japanese).

Once we've decided on our models and field, we need to think about the relationships. Django allows you to define relationships that are one to one (OneToOneField), one to many (ForeignKey) and many to many (ManyToManyField).

With that in mind, the UML association diagram below shows the models we'll define in this case (as boxes). As above, we've created models for book (the generic details of the book), book instance (status of specific physical copies of the book available in the system), and author. We have also decided to have a model for genre, so that values can be created/selected through the admin interface. We've decided not to have a model for the BookInstance:status — we've hard coded the values (LOAN_STATUS) because we don't expect these to change. Within each of the boxes you can see the model name, the field names and types, and also the methods and their return types.

The diagram also shows the relationships between the models, including their *multiplicities*. The multiplicities are the numbers on the diagram showing the numbers (maximum and minimum) of each model that may be present in the relationship. For example, the connecting line between the boxes shows that Book and a Genre are related. The numbers close to the Book model show that a book must have one or more Genres (as many as you like) , while the numbers on the other end of the line next to the Genre show that it can have zero or more associated books.



Note: The next section provides a basic primer explaining how models are defined and used. As you read it, consider how we will construct each of the models in the diagram above.

Model primer

This section provides a brief overview of how a model is defined and some of the more important fields and field arguments.

Model definition

Models are usually defined in an application's **models.py** file. They are implemented as subclasses of django.db.models.Model, and can include fields, methods and metadata. The code fragment below shows a "typical" model, named MyModelName:

```
from django.db import models

class MyModelName(models.Model):
    """
    A typical class defining a model, derived from the Model class.
    """

    # Fields
    my_field_name = models.CharField(max_length=20, help_text="Enter field documentation")
    ...

    # Metadata
    class Meta:
        ordering = ["-my_field_name"]

    # Methods
    def get_absolute_url(self):
        """
        Returns the url to access a particular instance of MyModelName.
        """
        return reverse('model-detail-view', args=[str(self.id)])

    def __str__(self):
        """
        String for representing the MyModelName object (in Admin site etc.)
        """
        return self.field_name
```

In the below sections we'll explore each of the features inside the model in detail:

Fields

A model can have an arbitrary number of fields, of any type — each one represents a column of data that we want to store in one of our database tables. Each database record (row) will consist of one of each field value. Let's look at the example seen above:

```
my_field_name = models.CharField(max_length=20, help_text="Enter field documentation")
```

Our above example has a single field called my_field_name, of type models.CharField — which means that this field will contain strings of alphanumeric characters. The field types are assigned using specific classes, which determine the type of record that is used to store the data in the database, along with validation criteria to be used when values are received from an HTML form (i.e. what constitutes a valid value). The field types can also take arguments that further specify how the field is stored or can be used. In this case we are giving our field two arguments:

- max_length=20 — States that the maximum length of a value in this field is 20 characters.
- help_text="Enter field documentation" — provides a text label to display to help users know what value to provide when this value is to be entered by a user via an HTML form.

The field name is used to refer to it in queries and templates. Fields also have a label, which is either specified as an argument (verbose_name) or inferred by capitalising the first letter of the field's variable name and replacing any underscores with a space (for example my_field_name would have a default label of *My field name*).

The order that fields are declared will affect their default order if a model is rendered in a form (e.g. in the Admin site), though this may be overridden.

Common field arguments

The following common arguments can be used when declaring many/most of the different field types:

- help_text: Provides a text label for HTML forms (e.g. in the admin site), as described above.
- verbose_name: A human-readable name for the field used in field labels. If not specified, Django will infer the default verbose name from the field name.
- default: The default value for the field. This can be a value or a callable object, in which case the object will be called every time a new record is created.
- null: If True, Django will store blank values as NULL in the database for fields where this is appropriate (a CharField will instead store an empty string). The default is False.
- blank: If True, the field is allowed to be blank in your forms. The default is False, which means that Django's form validation will force you to enter a value. This is often used with null=True , because if you're going to allow blank values, you also want the database to be able to represent them appropriately.
- choices: A group of choices for this field. If this is provided, the default corresponding form widget will be a select box with these choices instead of the standard text field.
- primary_key: If True, sets the current field as the primary key for the model (A primary key is a special database column designated to uniquely identify all the different table records). If no field is specified as the primary key then Django will automatically add a field for this purpose.

There are many other options — you can view the full list of field options here.

Common field types

The following list describes some of the more commonly used types of fields.

- CharField is used to define short-to-mid sized fixed-length strings. You must specify the max_length of the data to be stored.
- TextField is used for large arbitrary-length strings. You may specify a max_length for the field, but this is used only when the field is displayed in forms (it is not enforced at the database level).
- IntegerField is a field for storing integer (whole number) values, and for validating entered values as integers in forms.
- DateField and DateTimeField are used for storing/representing dates and date/time information (as Python datetime.date in and datetime.datetime objects, respectively). These fields can additionally declare the (mutually exclusive) parameters auto_now=True (to set the field to the current date every time the model is saved), auto_now_add (to only set the date when the model is first created) , and default (to set a default date that can be overridden by the user).

- EmailField is used to store and validate email addresses.
- FileField and ImageField are used to upload files and images respectively (the ImageField simply adds additional validation that the uploaded file is an image). These have parameters to define how and where the uploaded files are stored.
- AutoField is a special type of IntegerField that automatically increments. A primary key of this type is automatically added to your model if you don't explicitly specify one.
- ForeignKey is used to specify a one-to-many relationship to another database model (e.g. a car has one manufacturer, but a manufacturer can make many cars). The "one" side of the relationship is the model that contains the key.
- ManyToManyField is used to specify a many-to-many relationship (e.g. a book can have several genres, and each genre can contain several books). In our library app we will use these very similarly to ForeignKeys, but they can be used in more complicated ways to describe the relationships between groups. These have the parameter on_delete to define what happens when the associated record is deleted (e.g. a value of models.SET_NULL would simply set the value to NULL).

There are many other types of fields, including fields for different types of numbers (big integers, small integers, floats), booleans, URLs, slugs, unique ids, and other "time-related" information (duration, time, etc.). You can view the full list here.

Metadata

You can declare model-level metadata for your Model by declaring class Meta, as shown.

```
class Meta:
    ordering = ["-my_field_name"]
    ...
```

One of the most useful features of this metadata is to control the *default ordering* of records returned when you query the model type. You do this by specifying the match order in a list of field names to the ordering attribute, as shown above. The ordering will depend on the type of field (character fields are sorted alphabetically, while date fields are sorted in chronological order). As shown above, you can prefix the field name with a minus symbol (-) to reverse the sorting order.

So as an example, if we chose to sort books like this by default:

```
ordering = ["title", "-pubdate"]
```

the books would be sorted alphabetically by title, from A-Z, and then by publication date inside each title, from newest to oldest.

Another common attribute is verbose_name, a verbose name for the class in singular and plural form:

```
verbose_name = "BetterName"
```

Other useful attributes allow you to create and apply new "access permissions" for the model (default permissions are applied automatically), allow ordering based on another field, or to declare that the class is "abstract" (a base class that you cannot create records for, and will instead be derived from to create other models).

Many of the other metadata options control what database must be used for the model and how the data is stored (these are really only useful if you need to map a model to an existing database).

The full list of metadata options are available here: Model metadata options (Django docs).

Methods

A model can also have methods.

Minimally, in every model you should define the standard Python class method __str__() to return a human-readable string for the each object. This string is used to represent individual records in the administration site (and anywhere else you need to refer to a model instance). Often this will return a title or name field from the model.

```
def __str__(self):
    return self.field_name
```

Another common method to include in Django models is get_absolute_url(), which returns a URL for displaying individual model records on the website (if you define this method then Django will automatically add a "View on Site" button to the model's record editing screens in the Admin site). A typical pattern for get_absolute_url() is shown below.

```
def get_absolute_url(self):
    """
    Returns the url to access a particular instance of the model.
    """
    return reverse('model-detail-view', args=[str(self.id)])
```

Note: Assuming you will use URLs like /myapplication/mymodelname/2 to display individual records for your model (where "2" is the id for a particular record), you will need to create a URL mapper to pass the response and id to a "model detail view" (which will do the work required to display the record). The reverse() function above is able to "reverse" your url mapper (in the above case named *'model-detail-view'*) in order to create an URL of the right format.

Of course to make this work you still have to write the URL mapping, view, and template!

You can also define any other methods you like, and call them from your code or templates (provided that they don't take any parameters).

Model management

Once you've defined your model classes you can use them to create, update, or delete records, and to run queries to get all records or particular subsets of records. We'll show you how to do that in the tutorial when we define our views, but here is a brief summary.

Creating and modifying records

To create a record you can define an instance of the model and then call save().

```
# Create a new record using the model's constructor.
a_record = MyModelName(my_field_name="Instance #1")

# Save the object into the database.
a_record.save()
```

Note: If you haven't declared any field as a primary_key, the new record will be given one automatically, with the field name id. You could query this field after saving the above record, and it would have a value of 1.

You can access the fields in this new record using the dot syntax, and change the values. You have to call save() to store modified values to the database.

```
# Access model field values using Python attributes.
print(a_record.id) #should return 1 for the first record.
```

```
print(a_record.my_field_name) # should print 'Instance #1'

# Change record by modifying the fields, then calling save().
a_record.my_field_name="New Instance Name"
a_record.save()
```

Searching for records

You can search for records that match a certain criteria using the model's objects attribute (provided by the base class).

Note: Explaining how to search for records using "abstract" model and field names can be a little confusing. In the discussion below we'll refer to a Book model with title and genre fields, where genre is also a model with a single field name.

We can get all records for a model as a QuerySet, using objects.all(). The QuerySet is an iterable object, meaning that it contains a number of objects that we can iterate/loop through.

```
all_books = Book.objects.all()
```

Django's filter() method allows us to filter the returned QuerySet to match a specified **text** or **numeric** field against a particular criteria. For example, to filter for books that contain "wild" in the title and then count them, we could do the following.

```
wild_books = Book.objects.filter(title__contains='wild')
number_wild_books = Book.objects.filter(title__contains='wild').count()
```

The fields to match and the type of match are defined in the filter parameter name, using the format: field_name__match_type (note the *double underscore* between title and contains above). Above we're filtering title with a case-sensitive match. There are many other types of matches you can do: icontains (case insensitive), iexact (case-insenstive exact match), exact (case-sensitive exact match) and in, gt (greater than), startswith, etc. The full list is here.

In some cases you'll need to filter on a field that defines a one-to-many relationship to another model(e.g. a ForeignKey). In this case you can "index" to fields within the related model with additional double underscores. So for example to filter for books with a specific genre pattern, you will have to index to the name through the genre field, as shown below:

```
books_containing_genre = Book.objects.filter(genre__name__icontains='fiction')  # Will match on: Fiction, Science fiction, non-fiction etc.
```

Note: You can use underscores (__) to navigate as many levels of relationships (ForeignKey/ManyToManyField) as you like. For example, a Book that had different types, defined using a further "cover" relationship might have a parameter name: type__cover__name__exact='hard'.

There is a lot more you can do with queries, including backwards searches from related models, chaining filters, returning a smaller set of values etc. For more information see Making queries (Django Docs).

Defining the LocalLibrary Models

In this section we will start defining the models for the library. Open *models.py (in /locallibrary/catalog/)*. The boilerplate at the top of the page imports the *models* module, which contains the model base class models.Model that our models will inherit from.

```
from django.db import models

# Create your models here.
```

Genre model

Copy the Genre model code shown below and paste it into the bottom of your models.py file. This model is used to store information about the book category — for example whether it is fiction or non-fiction, romance or military history, etc. As mentioned above, we've created the Genre as a model rather than as free text or a selection list so that the possible values can be managed through the database rather than being hard coded.

```
class Genre(models.Model):
    """
    Model representing a book genre (e.g. Science Fiction, Non Fiction).
    """
     name = models.CharField(max_length=200, help_text="Enter a book genre (e.g. Science Fiction, French Poetry etc.)")

    def __str__(self):
        """
        String for representing the Model object (in Admin site etc.)
        """
        return self.name
```

The model has a single CharField field (name), which is used to describe the genre (this is limited to 200 characters and has some help_text. At the end of the model we declare a __str__() method, which simply returns the name of the genre defined by a particular record. No verbose name has been defined, so the field will be called Name in forms.

Book model

Copy the Book model below and again paste it into the bottom of your file. The book model represents all information about an available book in a general sense, but not a particular physical "instance" or "copy" available for loan. The model uses a CharField to represent the book's title and isbn (note how the isbn specifies its label as "ISBN" using the first unnamed parameter because the default label would otherwise be "Isbn"). The model uses TextField for the summary, because this text may need to be quite long.

```
from django.urls import reverse #Used to generate URLs by reversing the URL patterns
```

```
class Book(models.Model):
    """
    Model representing a book (but not a specific copy of a book).
    """
    title = models.CharField(max_length=200)
    author = models.ForeignKey('Author', on_delete=models.SET_NULL, null=True)
    # Foreign Key used because book can only have one author, but authors can have multiple books
    # Author as a string rather than object because it hasn't been declared yet in the file.
    summary = models.TextField(max_length=1000, help_text="Enter a brief description of the book")
        isbn = models.CharField('ISBN',max_length=13, help_text='13 Character <a href="https://www.isbn-international.org/content/what-isbn">ISBN number</a>')
    genre = models.ManyToManyField(Genre, help_text="Select a genre for this book")
    # ManyToManyField used because genre can contain many books. Books can cover many genres.
    # Genre class has already been defined so we can specify the object above.

    def __str__(self):
        """
        String for representing the Model object.
        """
        return self.title


    def get_absolute_url(self):
        """
        Returns the url to access a particular book instance.
        """
        return reverse('book-detail', args=[str(self.id)])
```

The genre is a ManyToManyField, so that a book can have multiple genres and a genre can have many books. The author is declared as ForeignKey, so each book will only have one author, but an author may have many books (in practice a book might have multiple authors, but not in this implementation!)

In both field types the related model class is declared as the first unnamed parameter using either the model class or a string containing the name of the related model. You must use the name of the model as a string if the associated class has not yet been defined in this file before it is referenced! The other parameters of interest in the author field are null=True, which allows the database to store a Null value if no author is selected, and on_delete=models.SET_NULL, which will set the value of the author to Null if the associated author record is deleted.

The model also defines __str__() , using the book's title field to represent a Book record. The final method, get_absolute_url() returns a URL that can be used to access a detail record for this model (for this to work we will have to define a URL mapping that has the name book-detail, and define an associated view and template).

BookInstance model

Next, copy the BookInstance model (shown below) under the other models. The BookInstance represents a specific copy of a book that someone might borrow, and includes information about whether the copy is available or on what date it is expected back, "imprint" or version details, and a unique id for the book in the library.

Some of the fields and methods will now be familiar. The model uses

- ForeignKey to identify the associated Book (each book can have many copies, but a copy can only have one Book).
- CharField to represent the imprint (specific release) of the book.

```
import uuid # Required for unique book instances

class BookInstance(models.Model):
    """
    Model representing a specific copy of a book (i.e. that can be borrowed from the library).
    """
    id = models.UUIDField(primary_key=True, default=uuid.uuid4, help_text="Unique ID for this particular book across whole library")
    book = models.ForeignKey('Book', on_delete=models.SET_NULL, null=True)
    imprint = models.CharField(max_length=200)
    due_back = models.DateField(null=True, blank=True)

    LOAN_STATUS = (
        ('m', 'Maintenance'),
        ('o', 'On loan'),
        ('a', 'Available'),
        ('r', 'Reserved'),
    )

    status = models.CharField(max_length=1, choices=LOAN_STATUS, blank=True, default='m', help_text='Book availability')

    class Meta:
        ordering = ["due_back"]


    def __str__(self):
        """
        String for representing the Model object
        """
        return '%s (%s)' % (self.id,self.book.title)
```

We additionally declare a few new types of field:

- UUIDField is used for the id field to set it as the primary_key for this model. This type of field allocates a globally unique value for each instance (one for every book you can find in the library).
- DateField is used for the due_back date (at which the book is expected to come available after being borrowed or in maintenance). This value can be blank or null (needed for when the book is available). The model metadata (Class Meta) uses this field to order records when they are returned in a query.
- status is a CharField that defines a choice/selection list. As you can see, we define a tuple containing tuples of key-value pairs and pass it to the choices argument. The value in a key/value pair is a display value that a user can select, while the keys are the values that are actually saved if the option is selected. We've also set a default value of 'm' (maintenance) as books will initially be created unavailable before they are stocked on the shelves.

The model __str__() represents the BookInstance object using a combination of its unique id and the associated Book's title.

Note: A little Python:

- The value returned by __str__() is a *formatted string*. Within the string we use %s to declare "placeholders'. After the string we specify % and then a tuple containing the values to be inserted in the placeholders. If you just have one placeholder then you can omit the tuple — e.g. 'My value: %s' % variable.

  Note also that although this approach is perfectly valid, please be aware that it is no longer prefered. Since Python 3 you should instead use the format method, eg. '{0} ({1})'.format(self.id,self.book.title). You can read more about it here. Starting with Python 3.6 you can also use the string interpolation syntax, e.g. f'{self.id} ({self.book.title})'.

Author model

Copy the Author model (shown below) underneath the existing code in **models.py**.

All of the fields/methods should now be familiar. The model defines an author as having a first name, last name, date of birth, and (optional) date of death. It specifies that by default the __str__() returns the name in *last name*, *firstname* order. The get_absolute_url() method reverses the author-detail URL mapping to get the URL for displaying an individual author.

```
class Author(models.Model):
    """
    Model representing an author.
    """
    first_name = models.CharField(max_length=100)
    last_name = models.CharField(max_length=100)
    date_of_birth = models.DateField(null=True, blank=True)
    date_of_death = models.DateField('Died', null=True, blank=True)

    def get_absolute_url(self):
        """
        Returns the url to access a particular author instance.
        """
        return reverse('author-detail', args=[str(self.id)])


    def __str__(self):
        """
        String for representing the Model object.
        """
        return '%s, %s' % (self.last_name, self.first_name)
```

Re-run the database migrations

All your models have now been created. Now re-run your database migrations to add them to your database.

```
python manage.py makemigrations
```

```
python manage.py migrate
```

Registering models

First, open **admin.py** in the catalog application (**/locallibrary/catalog/admin.py**). It currently looks like this — note that it already imports django.contrib.admin:

```
from django.contrib import admin


# Register your models here.
```

Register the models by copying the following text into the bottom of the file. This code simply imports the models and then calls admin.site.register to register each of them.

```
from .models import Author, Genre, Book, BookInstance


admin.site.register(Book)
admin.site.register(Author)
admin.site.register(Genre)
admin.site.register(BookInstance)
```

Note: If you accepted the challenge to create a model to represent the natural language of a book (see the models tutorial article), import and register it too!

This is the simplest way of registering a model, or models, with the site. The admin site is highly customisable, and we'll talk more about the other ways of registering your models further down.

Creating a superuser

In order to log into the admin site, we need a user account with *Staff* status enabled. In order to view and create records we also need this user to have permissions to manage all our objects. You can create a "superuser" account that has full access to the site and all needed permissions using **manage.py**.

Call the following command, in the same directory as **manage.py**, to create the superuser. You will be prompted to enter a username, email address, and *strong* password.

```
python manage.py createsuperuser
```

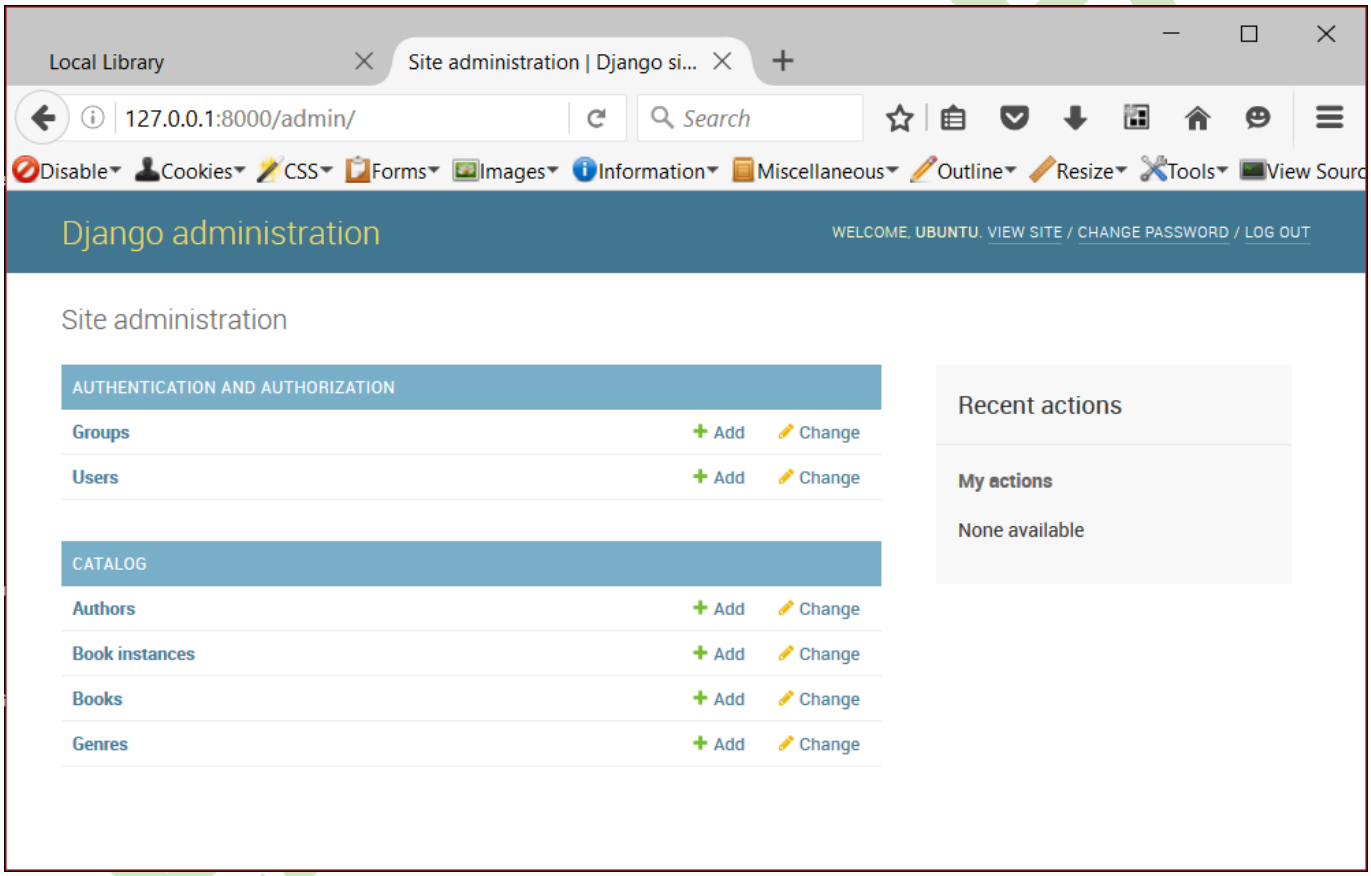
Once this command completes a new superuser will have been added to the database. Now restart the development server so we can test the login:

```
python manage.py runserver
```

Logging in and using the site

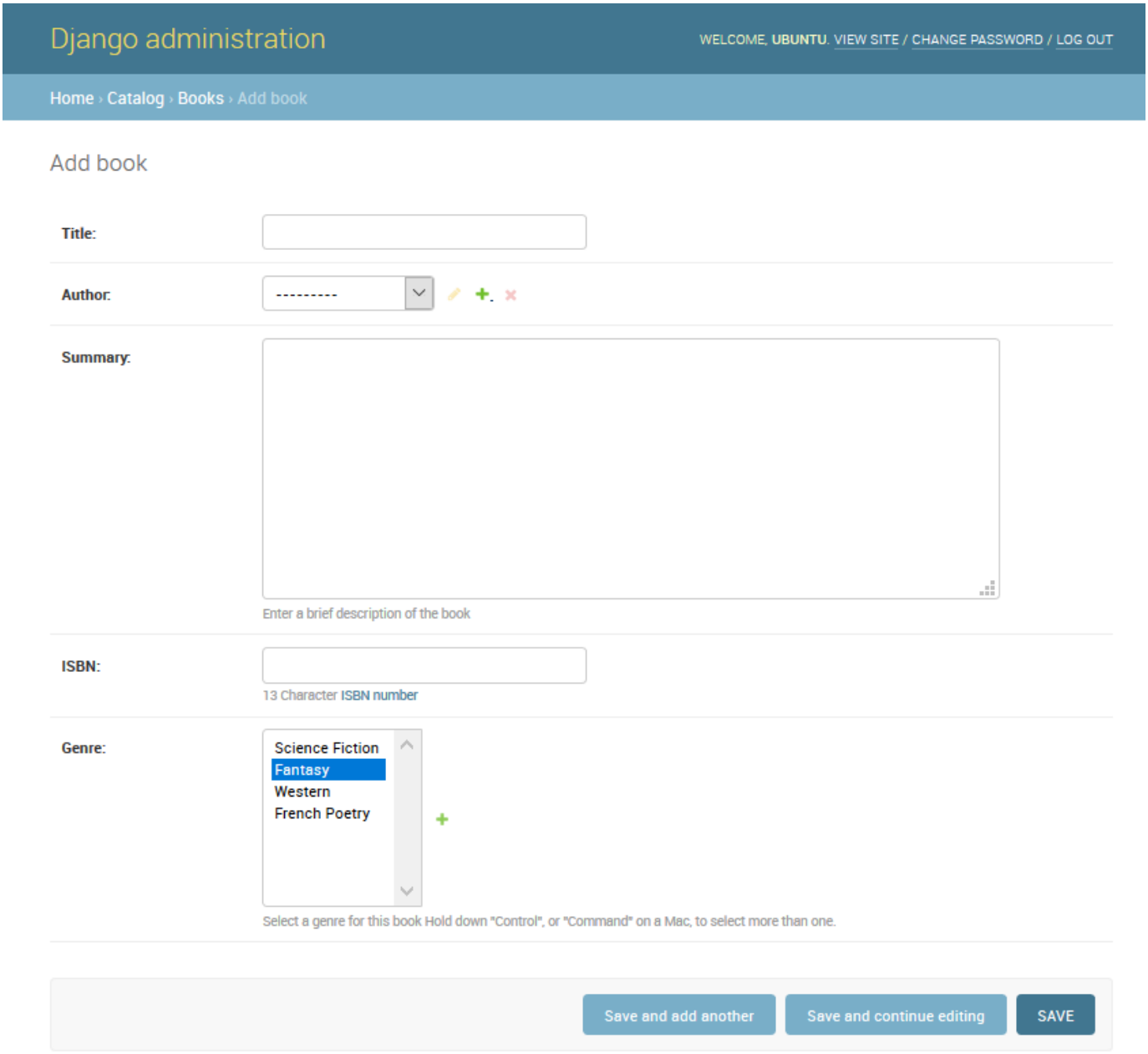
To login to the site, open the */admin* URL (e.g. http://127.0.0.1:8000/admin) and enter your new superuser userid and password credentials (you'll be redirected to the *login* page, and then back to the */admin* URL after you've entered your details).

This part of the site displays all our models, grouped by installed application. You can click on a model name to go to a screen that lists all its associated records, and you can further click on those records to edit them. You can also directly click the **Add** link next to each model to start creating a record of that type.



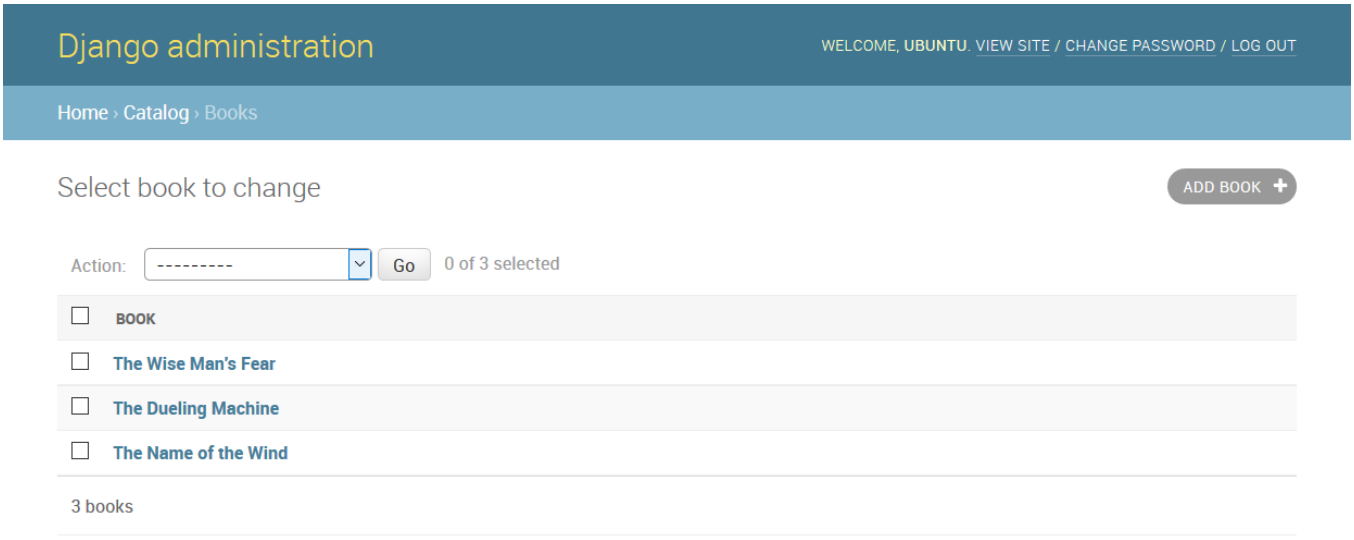
Click on the **Add** link to the right of *Books* to create a new book (this will display a dialog much like the one below). Note how the titles of each field, the type of widget used, and the help_text (if any) match the values you specified in the model.

Enter values for the fields. You can create new authors or genres by pressing the **+** button next to the respective fields (or select existing values from the lists if you've already created them). When you're done you can press **SAVE**, **Save and add another**, or **Save and continue editing** to save the record.



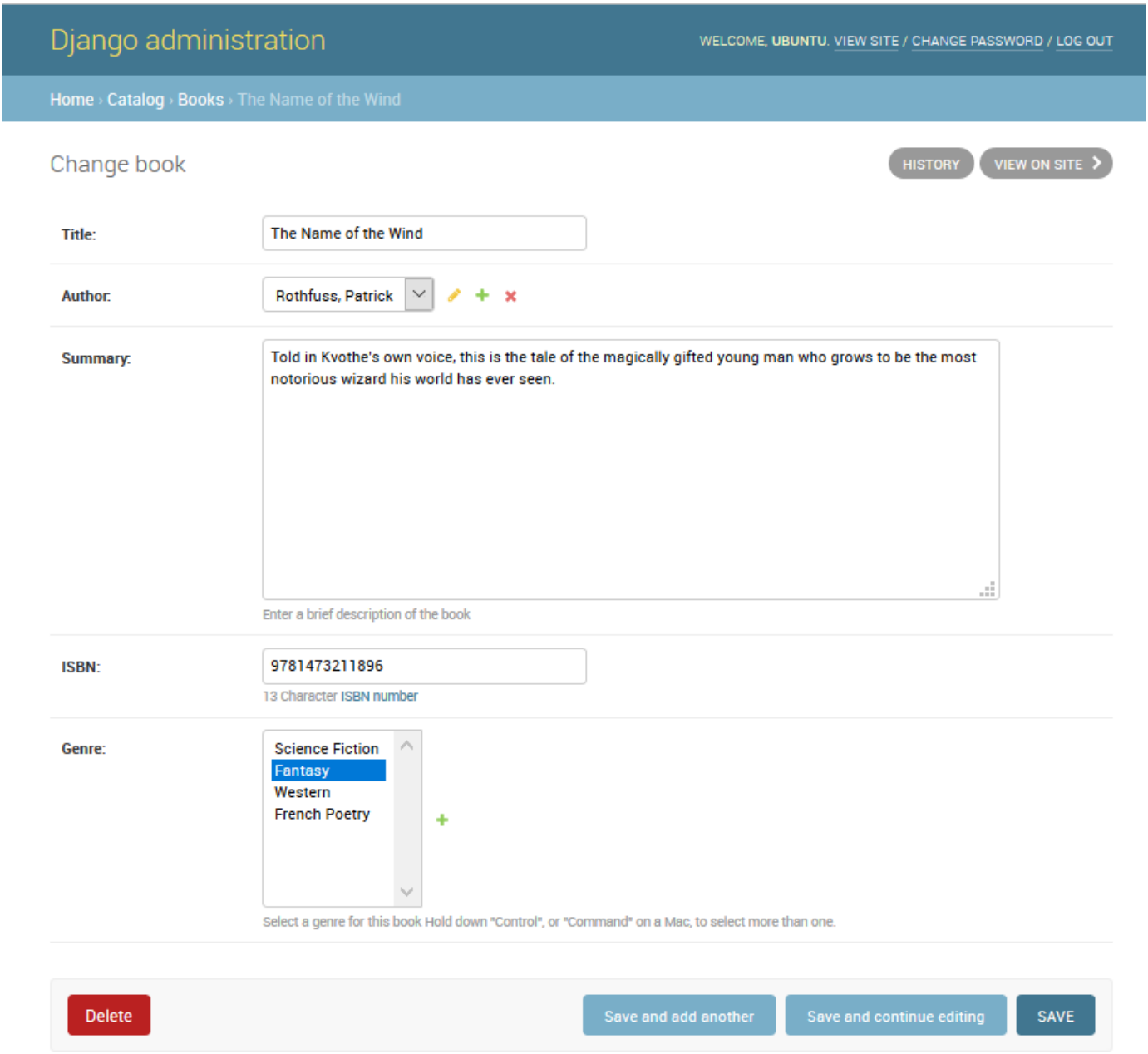
Note: At this point we'd like you to spend some time adding a few books, authors, and genres (e.g. Fantasy) to your application. Make sure that each author and genre includes a couple of different books (this will make your list and detail views more interesting when we implement them later on in the article series).

When you've finished adding books, click on the **Home** link in the top bookmark to be taken back to the main admin page. Then click on the **Books** link to display the current list of books (or on one of the other links to see other model lists). Now that you've added a few books, the list might look similar to the screenshot below. The title of each book is displayed; this is the value returned in the Book model's __str__() method that we specified in the last article.



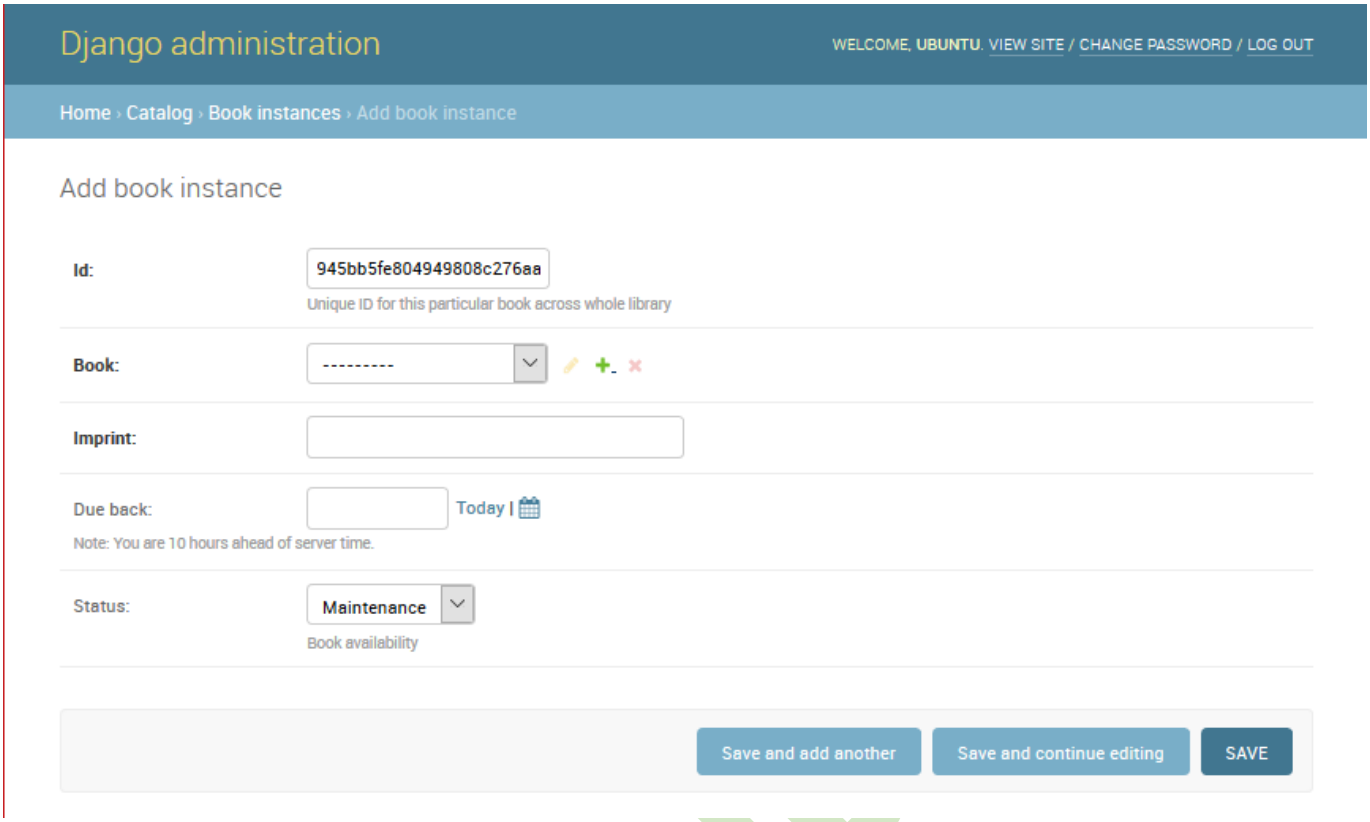
From this list you can delete books by selecting the checkbox next to the book you don't want, selecting the *delete...* action from the *Action* drop-down list, and then pressing the **Go** button. You can also add new books by pressing the **ADD BOOK** button.

You can edit a book by selecting its name in the link. The edit page for a book, shown below, is almost identical to the "Add" page. The main differences are the page title (*Change book*) and the addition of **Delete**, **HISTORY** and **VIEW ON SITE** buttons (this last button appears because we defined the get_absolute_url() method in our model).



Now navigate back to the **Home** page (using the *Home* link the breadcrumb trail) and then view the **Author** and **Genre** lists — you should already have quite a few created from when you added the new books, but feel free to add some more.

What you won't have is any *Book Instances*, because these are not created from Books (although you can create a Book from a BookInstance — this is the nature of the ForeignKey field). Navigate back to the *Home* page and press the associated **Add** button to display the *Add book instance* screen below. Note the large, globally unique Id, which can be used to separately identify a single copy of a book in the library.



Create a number of these records for each of your books. Set the status as *Available* for at least some records and *On loan* for others. If the status is **not** *Available*, then also set a future *Due back* date.

That's it! You've now learned how to set up and use the administration site. You've also created records for Book, BookInstance, Genre, and Author that we'll be able to use once we create our own views and templates.