

SkEye

Planetarium and PUSHTO guide for Android

Written for **SkEye Pro 2.1**
and **SkEye Free 5.1**

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INTRODUCTION

SkEye is a mobile planetarium software for Android phones. It can orient its view using sensors available on the phone.

With **SkEye**, you can use your phone as a finder-scope for telescopes, binoculars and other observing equipment.

Note that the Virtual-DSC is the main innovative feature in **SkEye**. The initial development effort has been focused on it. Other features that are typical in a planetarium are now being developed.

A note about Accuracy

The accuracy of **SkEye** is affected by a number of factors, both internal and external.

The external factors have the maximum effect and include the following:

- Accuracy of the phone's sensors and environmental effects such as surrounding magnetic fields (for Virtual DSC mode only).
- Mounting errors (for Real DSC mode only)

The effect of external factors can be mitigated to a large extent by multiple alignments.

Internally, **SkEye** is yet to account for the following (tiny) effects:

- Atmospheric refraction (which is most evident near the horizon)
- Proper motions of stars.

Operational Modes

- **Virtual-DSC**

This is the most innovative feature in **SkEye**. It is the cheaper, convenient (and possibly less accurate) alternative to real DSCs. After attaching your phone to the telescope OTA, you can use it as a finder-scope and a PUSHTO guide, without any additional equipment. Please make sure you read the detailed tutorial below before using it.

- **Hand-held mode**

Users of **Google SkyMap** would be familiar with this mode. It lets you quickly identify objects visible in the sky as well as search for them.

- **Bluetooth DSC**

Support for Digital Setting Circles connected over Bluetooth is in the works. (Checkout the "DSC test" app in the Android Market).

MAGNETOMETER CALIBRATION

IMPORTANT: Please read this section before using **SkEye**. It is a simple procedure but a crucial one for the proper operation of **SkEye** on some phones.

Android phones are equipped with a device called a Magnetometer. This device helps to determine the orientation of the phone relative to the Earth's magnetic field. (Similar to a compass needle but in three dimensions).

The magnetometer on some phones requires to be calibrated. *This needs to be done every time you use an app that needs the magnetometer!*

Calibration procedure

The procedure is very simple and takes just a few seconds. After starting the application, wave your arm (holding the phone) in a figure-8 motion. You may have to repeat this a couple of times.

This is best illustrated with [a video](#). (If you can't click the link, try searching **YouTube** for “best compass calibration method”).

After doing so, check whether North as shown in the app, is approximately where you think it is. (When the sensors are not calibrated, you will see really wild errors that are easy to notice).

SUBSTANCES THAT CAUSE INTERFERENCE

Since the operation of **SkEye** is affected by interference from metals, it is worthwhile to understand this phenomenon in brief.

Every substance interacts with ambient magnetic fields (such as the Earth's magnetic field) in a unique way. Their level of interaction is measured by the “relative magnetic permeability” of the substance. Higher the value, the more the substance distorts ambient magnetic fields. The relative permeability of some materials can be found in [this wikipedia article](#).

Among the commonly found materials the following are cause for concern in our context:

- **Iron**
- **Nickel**
- **Cobalt**
- Alloys of the above. For example, **Steel**.

All other materials *don't* pose a problem. Examples are:

- **Aluminum**
- **Copper** and it's alloys like **Brass**
- **Wood, Plastic** and most of the other commonly found substances

The latest versions of SkEye show a warning if abnormal magnetic fields are detected. This warning may only be shown in certain directions. You should consider changing the location of the phone, whenever it is shown.

VIRTUAL DSC

The Virtual DSC mode uses only the sensors on your phone to guide the planetarium view.

Advantages over a real DSC

- Cheaper (if you already own an Android phone)
- Quicker to install and get started
- Less messy (no wires, batteries, etc)
- Isn't affected by mounting errors.

Disadvantage

Possibly less accurate than a real DSC. The source of the inaccuracy is in the magnetic field measurement.

Magnetometers sense the direction of Earth's magnetic field to provide orientation. There are various errors introduced at this stage:

- The Earth's magnetic field itself is not consistent. It varies from place to place, and time to time, quite unpredictably. The major components of the variation are more predictable and taken care of but smaller components aren't.
- There is often some magnetic interference from the environment, such as large metal structures, electric circuits, underground metal deposits, and so on.
- Some phones induce a magnetic field around themselves, affecting their own sensors.

In spite of all these caveats, I have found this method to be accurate to about 15 arc-minutes with single point alignment. With two or three alignment points, accuracy can be improved further to about 8 arc-minutes. Complete accuracy is possible under ideal conditions.

TUTORIAL FOR VIRTUAL DSC

Since **SkEye** is the only application (that I know of) with a Virtual DSC feature, I am writing a detailed step-by-step guide for using it. It's actually quite simple once you get familiar with it.

1. Prepare your phone

- Make sure the phone's **system time** is accurate to within a minute (if not seconds). You can use, for example, the **Navy Time** application to verify system time accuracy. (See Appendix A for more details)
- Start the **SkEye** application.
- You will be prompted for your **location** when you first start the app. Specify your precise location for maximum accuracy. I recommend you use GPS to specify the location. The locations you specify are remembered so you can use them quickly later.

If you specify the location manually, note that the input is in decimal degrees. Hence, a latitude of **15°30'** should be entered as **15.5** and **not 15.3!** You can use Google Maps to find the co-ordinates of your location.

- *Important!* Calibrate the magnetometer as described in the previous section.

Now attach the phone to the OTA, as described below.

2. Attach to telescope

- You need to attach your phone to the telescope's Optical Tube Assembly (OTA), such that the phone moves whenever the OTA moves. See figure below for an example.



- You can use a phone jacket (or case, holster, etc) and attach the jacket permanently to the OTA. That way, you can “plug-in” the phone quickly when needed. To attach the jacket to the OTA you can use, for example, Velcro or two sided tape.
Checkout several ideas contributed by users [on my website](#).
- **The direction in which you attach doesn't matter. The type of mount doesn't matter either.** Attach in such a way that the display is conveniently visible and operable.
- You will get best results if your telescope doesn't have steel¹ tubes or mounts, since they cause magnetic interference. If they do, try to attach the phone farthest from the metallic content.
- Try to observe from a location where there is little magnetic interference, for example, keep away from electric poles and wires, large buildings or steel railings.

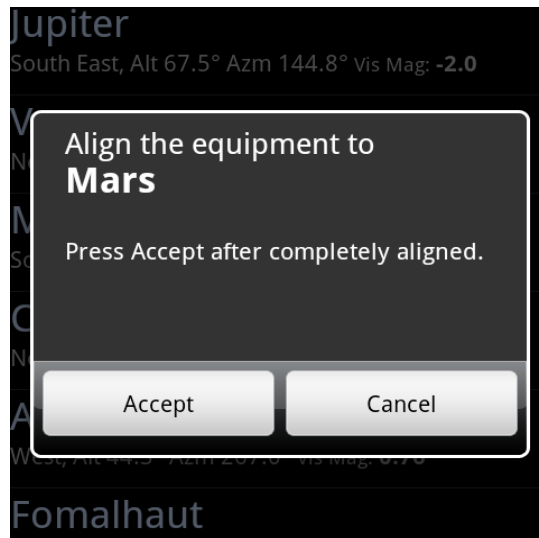
3. First Alignment

Although, in theory, you need just one alignment, you would be making about three alignments in practice. Choose a bright and well-known star/planet for your first alignment. **SkEye** automatically suggests targets for alignment when the object list is sorted by “ease of viewing”.

Click **Menu** button → **Indirect Mode** → **Add new Alignment**. You will see a list of objects sorted by their “ease of viewing”. SkEye prioritizes objects by their current altitude and visual magnitude.

Chose one of these objects and a dialog will show up asking for confirmation:

1 Not all metals are problematic. Read the note on “substances that cause interference”.



Now move your telescope so that this object is centered in the field-of-view. Only then, press **Accept**. Keep the telescope stationary for a few seconds, after clicking **Accept**. The alignment is done!

To help you to center the star in the field-of-view you can use an illuminated reticule eyepiece. If you don't have that you can use a high-power eyepiece and defocus it so that the star appears like a blob. Centering a large blob of light is easier than centering a pin-point source of light.

In the alignment screen click "**Return**" to get back to the planetarium view. The object you selected in the previous step should now appear in the center of the cross-hairs.

You have successfully made the first alignment. If you move the telescope now, you will see the display changing in tandem! You can now try finding a few objects or do more alignments as described in the next section.

4. Adding more Alignments

You can add more alignments by repeating the procedure above, but **SkEye** offers a quicker way to do this: **Insta-Align**. Here's how you use it.

Slew your scope to find another bright object. If there is a difference between the scope's view and the planetarium's view, you can simply drag the view until it is centered in the cross-hairs. The words **Insta-Align** will be shown along with a couple of buttons as in the figure below:



Once the object is centered, press the “+” button and you are done!

As a further shortcut, SkEye will show a button to align to the nearest object. For example the “**Align to Pollux**” button in the figure. This is handy and more precise than relying on your eyes to match the cross-hairs.

To cancel the alignment procedure you can click the red “X” button, or simply move the telescope away.

You can add as many alignment points as necessary. SkEye uses a weighted average of the alignment points, with the alignments nearest to current location having more weight.

TIP: Here is a typical observation session: Let's say I have made the first alignment to **Sirius**. Now, I try to find **M33**. But first, I will check the alignment in this direction. I see that there is a nearby star called **Mirach**. I get it into the FOV, and observe that **Mirach** is slightly off-center on the phone. I Insta-Align to it. When I push to **M33** using **SkEye** I see it right in the center of the FOV.

I can now find several objects in this part of the sky without checks or alignments. When I move to another part of the sky, it is time to check the alignment with a nearby bright star and Insta-align if needed.

FEATURES

There are many features packed inside **SkEye**, some of which may not be immediately obvious. I recommend reading or at least skimming through this section once.

NIGHT MODE

The night mode is designed to preserve dark adaptation. Invoked via **Menu** → **Toggle Night Mode**

Turning the night mode on changes the colors of the main display to a more reddish hue. On Android 2.2 and above, it also toggles the soft-key back light.

CATALOG FILTERS

Only available in SkEye Pro. Accessed via Menu → Catalogs.

With filters, you can choose which catalog objects are shown in the display based on their surface brightness and size. In the case of Open Clusters, magnitude is used instead of surface brightness.

DOUBLE TAP TO LAUNCH MENU

Android has a dedicated menu button but on most phones this button requires a hard-press, which might disturb the telescope's or phone's alignment. As an alternative you can double tap anywhere on the screen to bring up the menu. (Tapping requires less force than pressing a button).

PRINCIPAL ORIENTATION

The default orientation of **SkEye**'s main screen is portrait. But if you prefer landscape, you can change it via the Settings screen. There is also an "Auto" mode which changes the orientation dynamically to match the phone's orientation, but beware, there is a noticeable pause while switching orientations.

FOV ANGLES

The FOV angles in the horizontal and vertical directions are shown in the HUD and updated when you zoom in or zoom out, or change the principal orientation.

SENSITIVITY SETTINGS

Each Android phone model has it's own hardware quirks. Especially, managing the direction sensors is tricky. If you find the display is too jerky or too laggy, **SkEye** lets you alter the sensitivity of each sensor. Seen **Appendix B** for more details.

SEARCH

You can search for any of the objects in SkEye's database. Click the search button or invoke via **Menu → Search**.

After selecting the object to search, an arrow is shown to guide you the target. Also shown are the Alt-Azm and RA-Dec co-ordinates and the delta angle between the current position and the target.

TIP: Searching can be used to Insta-align for the first alignment. Before the first alignment, the display might be completely out of sync with your telescope view, making it difficult to drag the planetarium view to the required object. By searching for the object you get a guiding reticle to help you drag the view to the target.

MANUAL MODE

When you drag your finger on the main display, SkEye switches to manual mode. You can move the view around by single touch gestures. You can even zoom and rotate the display with multi-touch gestures. Click the “Back” button to return to normal mode. Or click the “Align” button to align to the highlighted object (if you are using it with a telescope).

Accelerometer Calibration (discontinued)

Early versions of SkEye came with this feature. The latest versions of SkEye *don't* support it. When the accelerometer has a constant error, SkEye can correct for the error automatically (in aligned mode). When the error is not constant, it is not possible to correct for it though multiple alignments help to a certain extent.

MISC FEATURES

- Precession of the equator calculated to arc-minute accuracy.
- Alt-azimuth and Equatorial grids.
- Real-time Alt/Azimuth, RA/HA/Dec coordinates
- Complete Messier catalog
- NGC Catalog
 - The Free version has a subset of NGC (the most prominent ~200 NGCs).
 - The Pro version has the complete NGC catalog.
- Intelligent positioning of labels that avoids overlap.
- Pinch to zoom in and zoom out (*on phones that support it*)
- Major star names

- Constellation lines and labels
- Multiple locations that are saved between sessions

APPENDIX A - MANAGING SYSTEM TIME

The accuracy of phone's system time is important for all planetarium apps. It is especially important in the case of **SkEye** since it uses real time object locations for alignment. If the time is wrong by a few minutes the errors add up, sometimes up to several degrees of bearing.

Normally, Android doesn't let applications change the system time. There are basically two choices to the user for setting the system time:

- Automatically set to network provided time (the mobile carrier network, not the Internet).

The problem with this is that the network's time may not be accurate or may not even exist in certain parts of the globe.

- Set to the time manually.

The problem with this is that the timer may drift over a period of time. So you will have to periodically check and reset the clock.

To check how accurate your system time is you can use a [GPS app](#) or the [Clock Sync](#) app (former uses GPS time while the other uses the Internet to access the atomic time).

I recommend the **Clock Sync** app. If you have a rooted phone, this app can automatically sync the system time to the atomic time. If you don't have a rooted phone, the app pops out notifications when the phone's time drifts too far from the atomic time.

APPENDIX B - ADJUSTING SENSITIVITY

How to adjust the sensitivity of the display.

First, start **SkEye** and calibrate the sensors with a figure 8 motion. Now observe the display for a few seconds.

In case of **too much jitter**, keep the phone on a level surface.

- If the jitter is such that the display **rotates** around the Nadir, then you need to reduce sensitivity of the **magnetometer**.
- If the jitter seems **random**, then you need to reduce the sensitivity of the **accelerometer**.

On the other hand, if there is **too much lag**, determine the direction of the lag.

- If there is a lag when moving along the horizon (azimuth change), you need to increase the sensitivity of the **magnetometer**.
- If there is a lag when going from horizon to Nadir (altitude change), then you need to increase the sensitivity of the **accelerometer**.