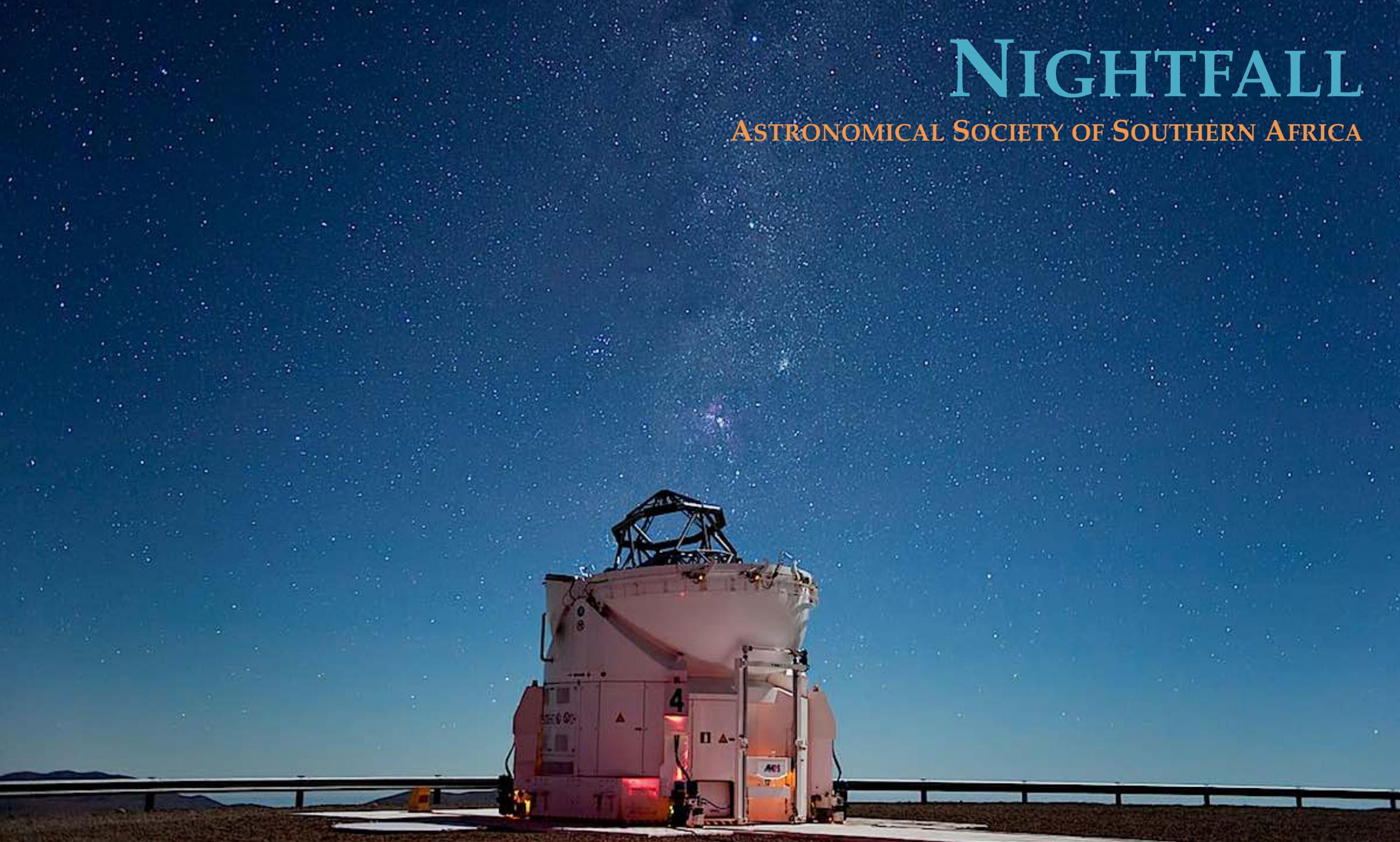


# NIGHTFALL

ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA



RESOURCE GUIDE FOR IMPROVING THE QUALITY  
OF ASTRONOMY EDUCATION IN SOUTH AFRICA

# NIGHTFALL

Astronomical Society of Southern Africa  
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## How Can We Improve Astronomy Education in South Africa?

- 1 - Astronomy craft websites for home schoolers and K, 1 - 4
- 2 - Astronomy Resources For the El-Hi Classroom
- 3 - Downloadable Astronomy Catalogues

# How to Improve Astronomy Education in South Africa

Astronomical Society of Southern Africa <https://assa.sao.ac.za/about/precollege/static/>

## Resources for astronomy applets and simulations

Observing the beauty and the science of the stars, planets, and galaxies is difficult for town dwellers. The night skies are dark while city lights are bright. Basic visual astronomy such as the shapes of the constellations and location of the moon and planets can be learned with a star chart and dim (preferably red) torch. The headband lamps used by bicyclists at night are reasonably priced and have both red and white light options. Binoculars introduce us to vast numbers of beautiful objects, but learning how to find them requires guidance in the form of an illustrated guide or working alongside someone who already knows the the positions of various objects among the constellations.

Astronomy can be made much easier using today's cellphones and tablet computers. For one, the slow rotation of the night sky can be quickly understood if it is speeded up to match our everyday TV, movie, and cellphone experience. **These days best starter kit is a cell phone or tablet with an internet connection.**

Today's astronomy-education teacher aids have become so sophisticated that it is easiest for a teacher to show a simulation to their learners before introducing the verbal descriptions and maths. Since astronomy education is such a big subject, we start with the basics — lesson plans, classroom activities, and the vast body of Applets and simulations.

Listed on the pages below is a get-acquainted sampler of the astonishing variety of educational materials that become immediately available by simply clicking on a link.

# Feet on the ground, eyes in the skies

Your own back yard could be the place to start your child to a journey that could last their lifetime. Ever since the first child looked up and pondered the heavens, kids across the ages have gazed at the moon and stars with a timeless sense of awe and wonder. When it comes time to be your turn to introduce your child to the marvels in the skies above, here are some things you can do.

## Preschool

With young children, it's usually best to begin with the basics. Grab some blankets or lawn chairs. As you lie under the stars, try these conversation starters:

- Look for landmarks in the sky. Where's the moon? Can you see the face of the man in the moon? Why does the moon change shape?
- Star light, star bright, is the first star you see tonight a star or a planet? What's the difference? (A star has its own light like a flashlight. A planet works like a mirror and reflects the light of the nearest star, our sun.)
- Bring the night sky indoors. Read nursery rhymes, poems, and other stories that talk about the stars and the moon. By the way, why did the cow jump over the moon?

## Elementary and Middle School

With school-age children, explore the constellations and the stars. Here are a few talking points to get things started:

- Constellations: Which ones can you identify? Each constellation has its own name, story, and legend: What are they? When are different constellations visible? Where do they rise in the sky? Are the constellations the same or different in the winter, spring, summer, and fall?
- Which days of the week are named after objects in the sky? (All of them!) Monday is the moon's day, Tuesday is named for Mars, Wednesday for Mercury, Thursday for Jupiter, Friday for Venus, Saturday for Saturn, and Sunday for the sun.
- Stars: Where is the brightest star? Is it the closest or farthest one?
- Is it a planet or a star?

## High School

Grab a pair of binoculars and your teenager, then head outdoors! With teens, the sky is the limit.

- Why are stars different colours? What do stars burn to make light? What are they made of? Do you know why they twinkle?
- Can you tell what time it is by the position of the stars in the sky?
- Looking at the stars is looking back in time. The light reaching your eyes may have begun its journey millions of years ago. What's the most distant star and the farthest back in time you can see?

## And on those awful nights when you have to come indoors

Next to a good pair of eyes, the Internet is the backyard stargazer's best friend. There are almost as many great websites devoted to astronomy as there are stars in the sky!.

# Section I – Astronomy craft websites for home schoolers and K-12

## Enchanted Learning (website, ages 6–16)

This website boasts some 35,000 web pages of articles and images devoted to nearly every topic a Grade 1 to Grade 12 learner will likely encounter in their studies. The sub-section devoted to Astronomy has about 900 web pages overall and describes nearly every topic in which a young learner might take interest. Some examples follow:

### All About Astronomy

[The Sun](#)

[The Moon](#)

[The Planets](#)

[Asteroids](#)

[Kuiper Belt](#)

[Comets & Meteors](#)

[Stars](#) (links to 15 detailed info websites & readables)

[Astronomers](#) (numerous capsule bios & pics)

[Worksheets & Activities printouts](#)

### Astronomy Crafts for Kids

- [Rhymes, Crafts, Quizzes, Information, and Printouts to Colour](#)
- [Sun-Related Rebus Rhymes](#)
- [Sun, Earth, and Moon Model](#)
- [The Solstice: Seasons and Axis Tilt](#)
- [Monthly activities calendars](#) (frequently updated & refreshed)

## Gift of Curiosity (website, ages 2–9)

This is a labour of love created by a mother of 2 who also has a Ph.D in childhood development.

[Activities](#) (make-it-yourself models, toys, colour books, etc.)

[Printables](#) (fee-based downloadable artwork for children to use).

[Thematic topics](#) (23 subjects e.g., geography, space, seasons, insects)

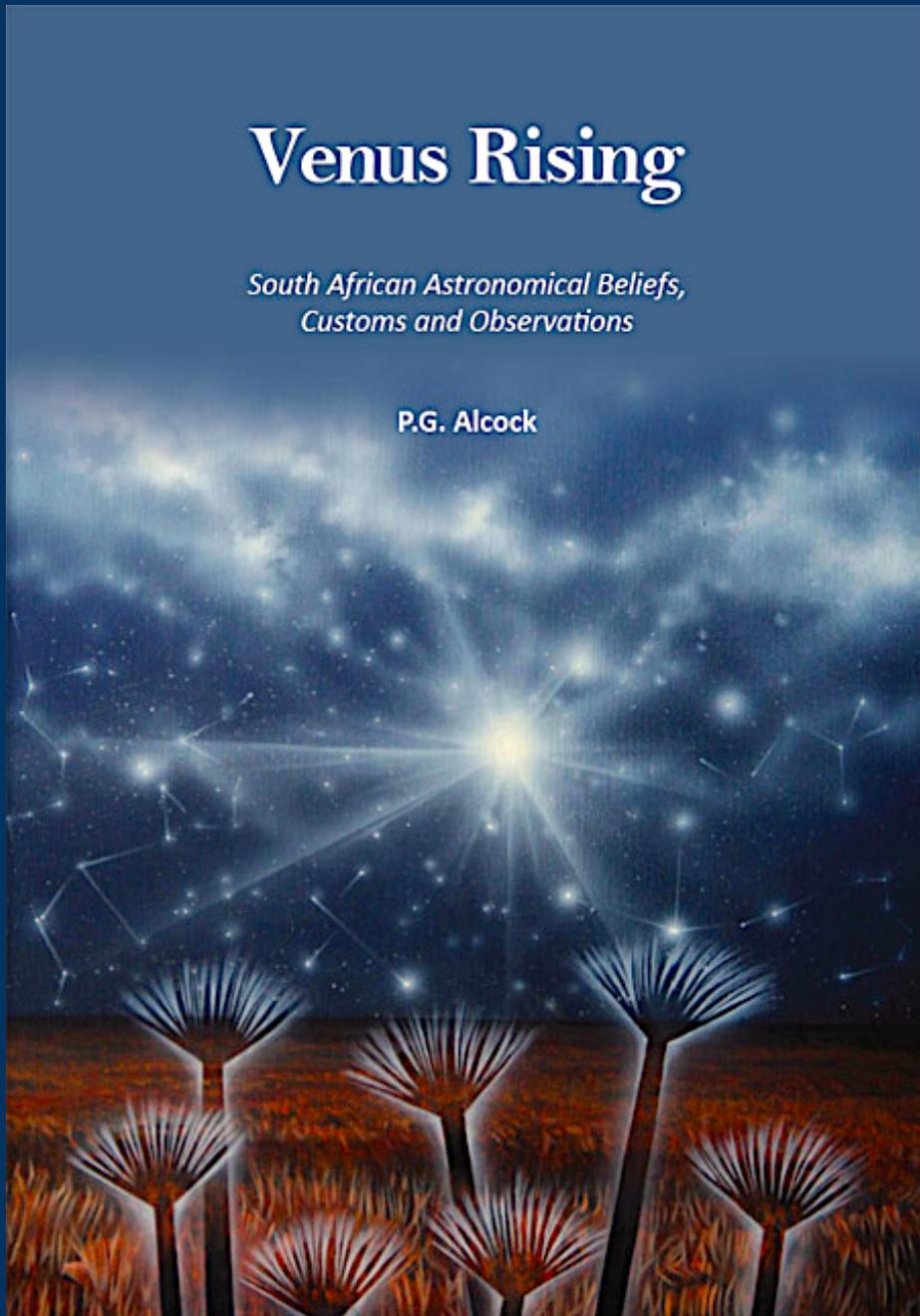
### Space Activities for Kids

- Kids will be familiar with the challenges faced by astronauts living and working in space
- Kids will recognise and be able to name all eight planets in our solar system
- Kids will learn about the sun, including the fact that it is a star, it provides energy for all life on Earth, and it sits at the center of our solar system
- Kids will learn about the moon, including the fact that people have visited it, it has no atmosphere, and its surface is filled with dusty craters
- Kids will learn about stars, including the fact that they are hot balls of gas and certain groups of stars form constellations

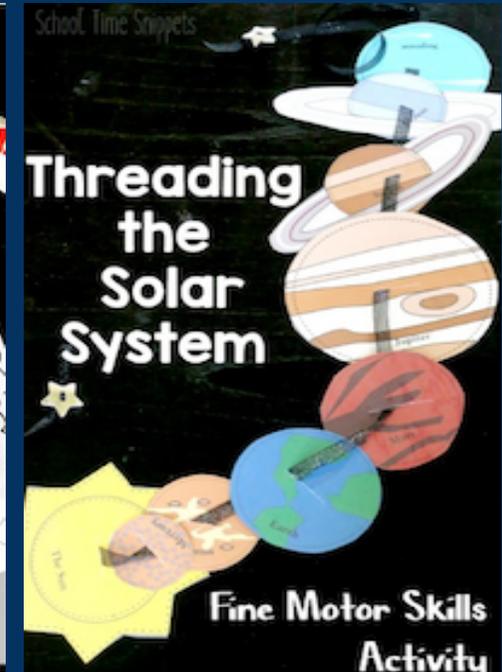
## Teach Beside Me (website, ages 3–11)

This hands-on website was developed by a school teacher whose experiences with teaching during the Covid-19 epidemic inspired her to use the Internet to teach youngsters about the night sky, space, and astronomy. This extensive array of DIY astronomy-related projects has even devised a way to illustrate the relative distances between the planets by adding up the numbers of squares in a measured length of a roll of toilet paper!

# Examples of websites that link to multiple educational resources



ASSA web page [African Ethnoastronomy](#)



Available on [Enchanted learning.com](#)

# ASTRONOMY

## ACTIVITIES for KIDS



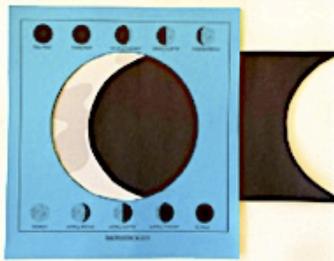
**STAR VIEWER**

**Solar System in a Jar**



TEACH BESIDE ME

**GRAVITY SPINNER TOY**



TEACH

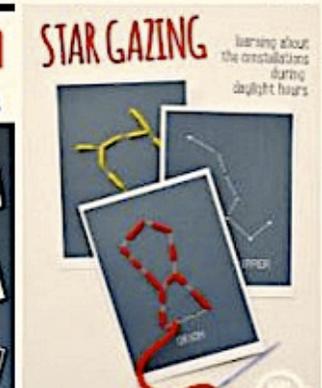
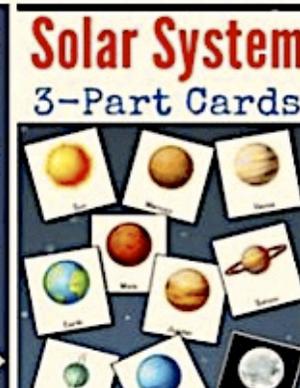
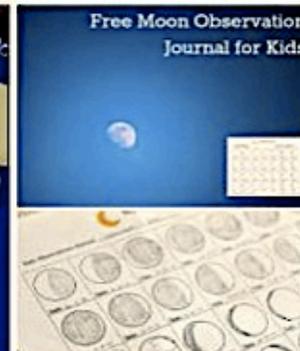
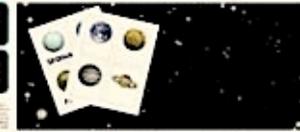
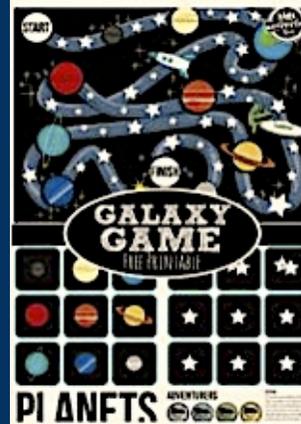


TEACH

Available on [Teach Beside Me.com](http://Teach Beside Me.com)

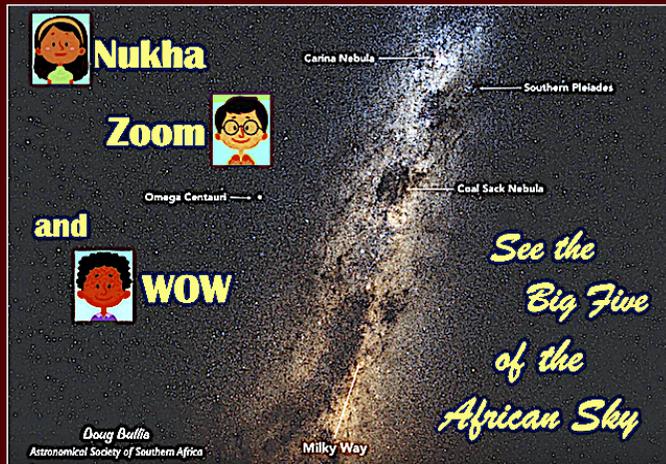
# SPACE & THE SOLAR SYSTEM

50+ kid-friendly & (mostly) free printables



Available on [Gift of curiosity.com](http://Gift of curiosity.com)

# Nukha, Zoom, and WOW see the Big 5 of the S. African Sky



A comic book for children 5 to 12. Produced and distributed at no cost by the Astronomical Society of Southern Africa.

## International Dark Sky Association

**CONSERVATION**

Our International Dark Sky Places program protects public and private lands from light pollution today and long into the future.

**DARK SKY-FRIENDLY LIGHTING**

Light can be used without polluting our natural night skies.

One People, One Sky  
We all share the same sky, and Astronomers Without Borders brings the world together to share our passion of astronomy and the wonders of the Universe.

Observing projects bring people together to share their activities with each other.

Support projects allow those in developed countries to share with others, making it possible for everyone to enjoy the wonders of the night sky.

### Member Reports

<p><b>Haldia Institute of Management Astronomy Club inaugurates its First Observatory</b></p> <p>Haldia Institute of Management Astronomy Club inaugurates its First Observatory</p> <p><a href="#">READ MORE...</a></p>	<p><b>Pakistan to convey the message of cosmos in regional languages</b></p> <p>Working in remote area of Pakistan to convey the message of cosmos in regional languages</p> <p><a href="#">READ MORE...</a></p>	<p><b>Asteroid Day Brazil 2021 Starts in Goiás</b></p> <p>Asteroid day Brazil starts in Goiás. Accepting yet another international...</p> <p><a href="#">READ MORE...</a></p>
<p><b>Se realizó el 2do encuentro de charlas astronómicas con los niños del círculo de lectura, la potencia a car...</b></p> <p>JAN 21</p> <p><a href="#">READ MORE...</a></p>	<p><b>Discovery of Supernova by Dr. Amit Manna</b></p> <p>Discovery of Supernova. This transient was discovered with the help of citizen science project Supernova Hunters</p> <p><a href="#">READ MORE...</a></p>	<p><b>Discovery of Supernova by Dr. Amit Manna</b></p> <p>Discovery of Supernova. This transient was discovered with the help of citizen science project Supernova Hunters</p> <p><a href="#">READ MORE...</a></p>
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## Programs

Participate in AWB's programs and share your passion for astronomy with amateur astronomers around the world.

- Community Based Programs**  
Community programs bring people together through our common interest in
- Arts and Culture Programs**  
Arts and Culture programs bridge the border between art and science, highlighting the
- Resource Sharing Programs**  
Resource-sharing programs provide the opportunity to share knowledge as well as

**Global Astronomy Month 2020**  
Global Astronomy Month is the world's largest annual celebration of astronomy.

[Astronomers Without Borders website](http://www.astronomerswithoutborders.org)

This and the following page are just two examples of the huge menu of the downloadables available from

[NASA's Space Place.](#)

Launched in 1998, NASA Space Place's mission is to inspire and enrich upper-elementary-aged kids' learning of space and Earth science online through fun games, hands-on activities, informative articles and engaging short videos. With material in both English and Spanish and resources for parents and teachers, NASA Space Place has something for everyone.

The screenshot shows the NASA Space Place website. At the top left is the NASA logo. To its right, the text reads "NASA Science" in a small font, "Space Place" in a large, bold font, and "Explore Earth and Space!" in a smaller font below it. Below the header is a navigation bar with six colorful icons: Earth (green), Sun (red), Solar System (purple), Universe (blue), Science and Tech (pink), and Educators (red). Each icon has a corresponding label below it. Below the navigation bar is a section titled "Parents & Educators" in a large, bold font. Underneath this title is a prominent orange banner with the text: "Mission To Mars Student Challenge: Take part in a worldwide 'teachable moment' and bring students along for the ride as NASA lands a rover on Mars February 18! [Click here to join the adventure with students worldwide!](#)". Below the banner is a grid of four buttons: "Crafts" (green, scissors icon), "Games" (blue, game controller icon), "Videos" (orange, play button icon), and "Subscribe" (purple, envelope icon). To the right of this grid is a white box titled "Other NASA Resources" containing a list of links: "NASA at Home", "NASA Space Place on YouTube", "NASA STEM Engagement", "JPL Education", "NASA eClips", "NASA Climate Kids", "Earth Observatory Kids", and "NASA Kids Club".

NASA Science  
**Space Place**  
Explore Earth and Space!

Earth Sun Solar System Universe Science and Tech Educators

## Parents & Educators

**Mission To Mars Student Challenge:** Take part in a worldwide "teachable moment" and bring students along for the ride as NASA lands a rover on Mars February 18! [Click here to join the adventure with students worldwide!](#)

**Crafts** **Games**  
**Videos** **Subscribe**

### Other NASA Resources

- NASA at Home
- NASA Space Place on YouTube
- NASA STEM Engagement
- JPL Education
- NASA eClips
- NASA Climate Kids
- Earth Observatory Kids
- NASA Kids Club



Scavenger Hunts



NASA Space Place Art Challenge!



NASA Coloring Pages



NASA Partner Programs



NASA Space Place Article Partner...



Make a Stained Glass Earth!



What Is a Meteor Shower?



Launch a rocket from a spinning...



What's the secret code for...



Next Generation Science Standards



Printed Product Downloads



Museums: Partner With NASA



Astronomy Clubs: Partner With NASA



NASA is not alone in space!



Share NASA Space Place



Write your own zany adventure story!



Lucy's Planet Hunt . .



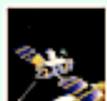
Printable Space Valentines



NASA Pumpkin Stencils



SCaN Kids Zone



Universe Spacecraft Paper Models



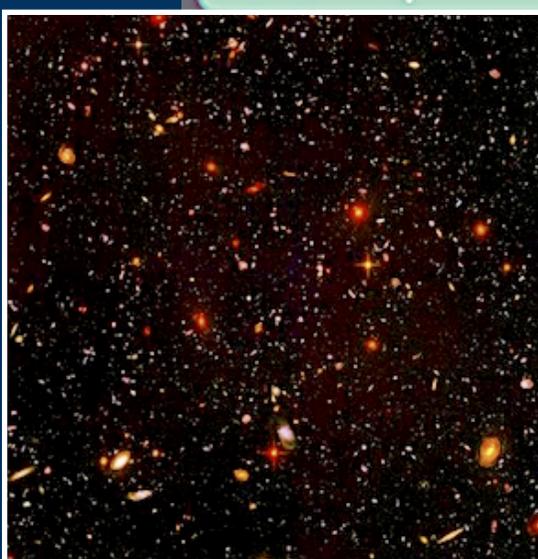
Explore Other Planets



## What is a galaxy?

We live on a planet called Earth that is part of our solar system. But where is our solar system? It's a small part of the Milky Way Galaxy.

And our galaxy is just one of millions and millions. Find out more about what a galaxy is and how many there are.



# A small sample of the multitude of flash cards, kits, ideas, and printables available on [Pinterest.com](https://www.pinterest.com).

**Pinhole Viewing Box**  
to safely view a solar eclipse  
Life with Home Based

**Puffy Paint Solar System Space Craft**  
Classroom Combs for Grades K-4  
NASA.gov brings you the latest images, videos and news from...

**STAR CRAFTS, ACTIVITIES, & RECIPES**  
AllDoneMonkey.com

**EARTH'S ROTATION & REVOLUTION**  
Hands-on Learning

**CHALK PASTEL METEOR SHOWER ART PROJECT**  
Chalk Pastel Art Chalk Pastels

**Phases of the Moon DIY Learning Toy**  
HANDS ON & FUN way to learn  
Kid Science 1st Grade Science  
Moon Phases Learning Toy  
Phases of the Moon Learning Toy

**20+ Moon Printables & Activities**  
3Dinosaurs.com  
Space Activities For Preschoolers  
20+ Moon Printables & Activities  
20+ Moon Printables & Activities - fun activities around...

**Moon Phases**  
GLUE RESIST WATERCOLOR PAINTING!  
chalkacademy.com

**Relative Sizes of Planets (Free Printable)**  
Kid Science Third Grade Science  
Planets Activities Solar System Activities

**Paint Stick Solar System**  
Paint Stick Solar System Project for Kids  
Paint Stick Solar System Project - this is such a fun way for kid...

**Preschool Learning Pack The Solar System**  
Solar System For Kids Solar System Activities  
Solar System Learning Kit - 3 Boys and a Dog, Shop  
Preschool Learning Pack - The Solar System: Teach your...

**Interactive Solar Eclipse Craft For Kids**  
Kid Science Science Experiments  
Solar Eclipse Craft  
Easy and fun craft to introduce Solar Eclipse to little kids...

**Explore MOON CRATERS with a HANDS-ON Learning Activity**  
Moon Activities Space Activities  
Poppin's Book Nook - Beyond Our Planet and...  
A fun hands-on way to explore moon craters and a book to g...

**Make a working TELESCOPE**  
Science Activities For Kids Preschool  
How to make a telescope  
Make a working telescope! Kids can learn to combine lenses of...

**PLANETS FOR PRESCHOOL**  
Space Stones: Playing with Planets for Preschool  
Study the planets with your preschooler with these durabl...

**Phases of the Moon Wreath**  
Space Activities For Kids Moon Activities  
Easy to Make Phases Of the Moon Wreath

**Printable Constellation Mats**  
Constellations for Kids  
Printable Constellation Mats in the Set  
10 Constellation Mats in the Set  
Printable Activities For Kids Kids  
Constellations for Kids - Printable Constellation...  
This simple set of constellations for kids printable constellation...

**EARTH'S ROTATION & REVOLUTION**  
Hands-on Learning

**Planet Order Easy Reader Book**

**EARTH'S ROTATION & REVOLUTION**  
Hands-on Learning

**GALAXY UNIT Planets Model**  
Moon Phases Learning Toy

**EARTH'S ROTATION & REVOLUTION**  
Hands-on Learning

# Cellphone & Tablet Apps



Digital Citizenship   EdTech Reviews   Professional Development & Advice

The aptly named **Common Sense Education** has a clickable list of 24 apps geared to learners K–12 with links, prices, & pocket summaries of their utility. Downloadable on Google Play & Apple App Store. Here are a few highlights, starting with K–2 on up to mid-undergrad:



**Ready Jet Go! Space Explorer.** Free download, a basic starter app for learners K–4. If the cell phone's location services setting is enabled, point the screen to the sky and you see the screen depict the real sky.



**Solar System Explorer.** Free download, school years 2–12. so well-produced, it should fascinate any kid even remotely interested in space. Superbly made interactive graphics make for truly serious engagement and continued interest.



**Sky Map.** Free download, excellent introduction to basic astronomy for kids who haven't explored space before. Partly a pocket planetarium that shows the real sky when the phone is pointed there, enhanced with attention-keeping photos and graphics.

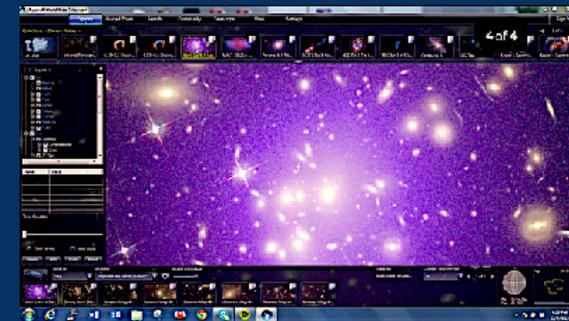
**DIY Sun Science.** Free, school years 2 – 8. Beautiful images, graphics, & videos make this a hands-on app. Click on the 'Sun Observatory' icon and you are whisked to a live image of the Sun in narrowband H-alpha. It's cheaper than a Coronado double etalon scope!



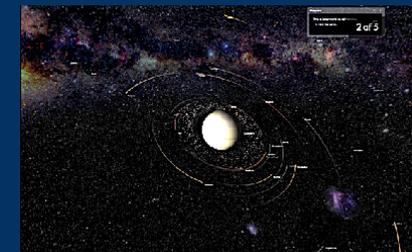
**Britannica Kids: Solar System.** US\$4.99, school years 3 to 12. Engaging games & eye-catching graphics get kids interested from the outset. Considerable amount of factual content.



**Worldwide Telescope.** Free download. Here we start getting into serious astronomy for upper-level learners in forms 9 up to varsity undergrad. Here is what happens when you take an astronomy textbook off a piece of paper and put it on an interactive cellphone screen. It's a whole new world. Lots of them, in fact.



**Sandbox Universe.** Free download, serious astronomy for learners from form 9 to undergrad. This app takes the 'thought experiment' or 'what if' approach using pre-set scenarios from which learners can apply



## Pocket Universe 6

This app is a portable sky map with numerous add-on features including augmented reality modes. The maps are clearly labelled and enable the ability to track individual objects and planets that are of particular interest. You can even use this app to explore the solar system on a particular night from the comfort of the comfy bed in your abode—helpful if the weather turns sour during your break. Pocket Universe comes with a wealth of extra activities and resources such as quizzes and facts useful for tedious family outings or as an evening activity during your holiday.



Among the top few astronomy apps on the market and an utter bargain at \$2.99. Appears to be a one-man-show labour of love by an astronomer who has excellent computer programming skills in addition to astronomy knowledge. The splash page opens to a tablet of nine boxes under a minimal maps—Tour, Sky, Moon Planets, Tonight, a 3D interactive Orrery, Extras (lots), and Augmented Reality. The 3D follow-the-camera sky maps are constellation outlines, star names, planet positions. The MW does not show star clouds, which is OK in this case because the screen is speckled with little gearwheel-like circles that when you move them into the centre wheel the various objects (Messiers mostly) expand into a sharp thumbnail photo of the cluster or whatever plus a capsule description of what it is, its RA & Dec, rise & set time, and current position in the sky in alt-az coordinates. The Tour functions swoops around the sky with stopovers at numerous objects to inform us what it is & why it is important—a great feature for beginners who want to learn the constellation and the main objects inside them.

## Night Sky

Amazingly good for a free product. Exclusive to iOS, Night Sky is a part of Apple's push for AR apps, producing a nice-looking augmented reality map of the sky. Notably, this application is supported by the Apple Watch, bringing the information to your wrist where it can be accessed with ease at any time, allowing you to avoid any distractions caused by your phone. Recently, the app has evolved to include an ARKit, which is basically a virtual model of the solar system that you can circle around and view as and when you like. Night Sky allows users to quickly identify stars, constellations, satellites and planets as well as weather conditions for the coming night. On top of this information, Night Sky has a community that provides suggestions for the best stargazing locations around the world! Opens with tutorial/setup page. Setup page 1 requires user's permission to turn on camera, calendar, notifications, & location. Page 2 are on/off buttons for the app's major features—music (soothing spacey chords), show satellites, real-sky presentation, trajectories & orbits, ecliptic. Next is ad page, \$3.99 month for full-blown version, or \$19.95/yr. The app began with a sky simulation of the Sun in with all the night-sky constellations (outline outside centre, artistic sketches when centred), 5 magnitude levels of stars, larger stars named, a few HD numbers and Messier objects. Take it outside & point up: soft blue & white colour scheme which does take a moment to adjust when moving from screen sky to real sky. Jupiter & Saturn match exact positions as seen by eye, Sco & Sagg on screen match real sky when camera aimed there. MW quite accurate in shape, comparative brightness with real sky, excellent rendering of dark clouds. Scutum & Norma star clouds not as bright on screen as real sky. Kids will have no problem relating the screen to the sky if the instructor uses a laser to point out where they should aim their cameras. The artwork accurately renders even the minor constellations (Indus) both in outline and in art-image form; the art is serious with no cartoonish effect as found in a some of the other apps.

## Kiwaka & Kiwaka Story

Kiwaka is a constellation finder designed just for the kids (although we adeptly reverted to childhood just looking at the thing!) Kiwaka Stories relates the diverse stories behind the 88 constellations, without the point-at-the-sky finder function of Kiwaka itself. Reasonably priced at \$2.99. The whimsical art and story lines are pure fun in addition to being fairly accurate guides to the constellation shapes, names, and histories. Developed in collaboration with the European Space Agency (ESA), the European Southern



Observatory (ESO) and other leading scientific organizations. Learn Astronomy and Greek Mythology with Kiwaka. Play it in the dark for a more delightful visual experience.

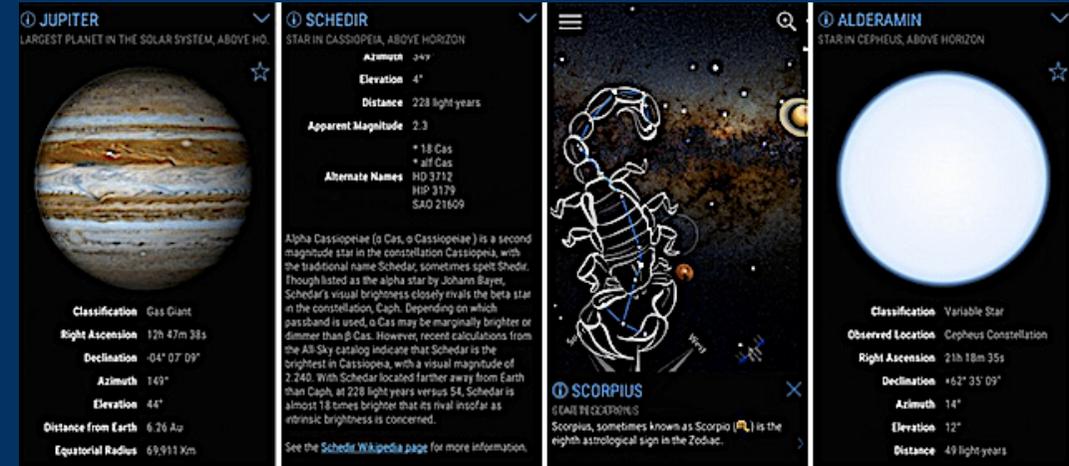
"It's part lesson and part game, really: kids catch fireflies in the game part to reveal stars, then learn about the myths" – [The Guardian](#)

"Mobile app company LANDKA brings the Universe closer" – [ESO](#)

"Visit the African jungle and go star-gazing with Kiwaka (...) Astronomy has never been so much fun." –

## SkyView

Available on both [Android](#) and [iOS](#) systems at no cost and is a good example of an ideal all-in-one guide to the night's sky. Using advanced technologies, the app uses sensors and the screen of your smartphone to provide an augmented reality perspective of what's up in the sky. These devices will often turn into AR viewfinders allowing you to identify any number of stars, planets and constellations. The app not only informs the user of the track in the sky but provides a detailed description of what it is and where it has come from.



Fascinatingly, this app also includes a feature that allows you to view the sky as it was in a time gone by and what it may look like in the future. SkyView users can simply point their device to the sky and instantly identify stars, constellations, and satellites. The app provides endless information on the world above and even provides notifications for upcoming stargazing events. opens with an ad for full version at \$1.99. Swipe left & you see why: bare-bones info, shows only Zodiacal constellations, albeit with realistic thumbnail overlays of planets & moon. Off-ecliptic you see only stars mag 2 & brighter. There is a circle in the screen centre about 5° in diameter. Move an object into it and the object ID comes up, planets & traditional Greek/Arabic star IDs. Screen images stark white on black background, requires several seconds to adjust when looking at real sky; there is a red-screen feature in the setup area, but then the screen is too faint to easily read it or see the constellation outlines. From what I saw it wasn't worth it to pay the \$1.99 for the full-feature version unless the detail and screen brightness are a real improvement.

## Star Chart

The free app for [iOS](#) and [Android](#) is minimal, but if you click past the icon you get basic info like on the right-hand boxes on Wiki pages. The sky map images do not compare well with the naked-eye view. Click on a screen object, e.g. M41 and you get a fairly comprehensive thumbnail including real-time RA & Dec

positions on sky. The Messier catalog edition costs \$9.99 but some of the object images (M10, M12) are so chubby and soft they look



like the eyepiece views that a visual astronomer sees on a night of awful seeing. Click on star you get Greek and Arabic IDs (Brachium is Sigma Libris, who knew?). The full version is a modest \$2.99, but then you find yourself in an add-on minefield: an upgrade to include solar information is \$4.99. Add comets for another \$2.99. Meteor shower dates and radiants are \$4.99. Add satellites for another \$4.99. The full version promises improved images and data but you have to find out by spending a lot of money first.

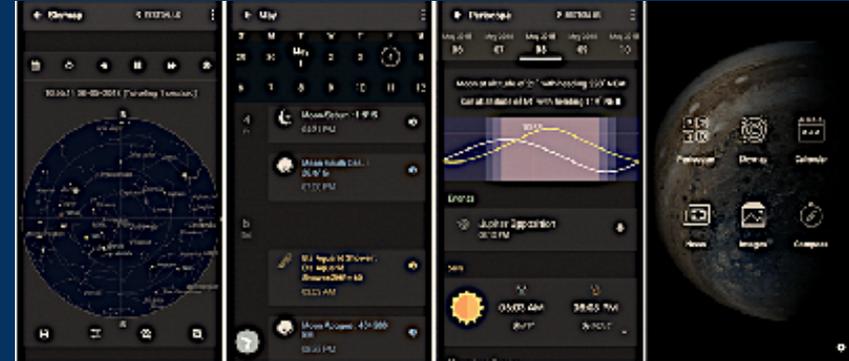
## Startracker

Opens to moving and panning real-sky maps w constellation outlines. The compass is about 40° to left of pole, hence the constellations shown on the sky view are 40° west of true position. (This is probably a fault in my cell phone, not the app, because similar issues occurred in other apps.) Milky Way reproduction, especially light & dark cloud positions are neither accurate nor detailed. The app does show thumbnail inserts of select Messier objects, e.g. M8, but clicking on a star or constellation name produces no response. The app appears to be marketed as a Messier finder for field use. No further info unless you buy the \$2.99 version. Maybe the full version has better artwork;

## SkyWiki

([Android](#) only). Although not exactly a planetarium simulator or VR stargazing app, SkyWiki has one of the best interfaces on this list. Easy to use, minimalist, and quite stunning, Sky Wiki also has numerous unique features. The Periscope page gives detailed information about Solar System objects in the sky as well as

any relevant astronomical events. The Calendar page gives more information about those events in addition to records of both past and



future events. However, some of the event details border on overly technical and often have jargon that beginning astronomers or just interested users may not know. The Images page displays the Astronomy Picture of the Day (APOD), NASA image of the day, Lunar image of the day, and Hubble picture of the week in an inspirational and accessible way to encourage users' passion for space. The Skymap feature is 2D, static star map more akin to a planisphere, especially compared to the interactive, enhanced reality modes that other apps offer. This app remains one of the best currently available.



## Sky Live

This is a single-purpose app devoted to your prospects for good seeing at your location tonight. The app opens to handsomely realistic photo imagery and informed my my seeing probability above Grahamstown was 85% at the time. I looked outside and it appeared quite a bit better, though I didn't look at any stars at 100x to make sure. The screen said 7 constellations were visible at the moment, plus Jupiter and Saturn. The \$0.99 upgrade to full version provides much more data, but the app remains a up-to-the-minute seeing predictor based on an unnamed weather database. Useful if you might want to take out the scope tonight, but of minimal use as a teaching aid.

## Starlight - Explore the Stars

While it lacks most of the features and customization options of its competitors, Starlight excels at what it aims to do. There are no detailed settings, no options, and no additional object information; the app is simply the night sky with the more prominent



constellations, stars, and planets labeled. The free version does have ads though, but they can be removed by purchasing the app for \$1.99 (Android only). Due to the minimalism and pared-down approach, this would be a useful app for introducing younger users to the night sky. Apart from that, however, Starlight lacks true appeal

## SkySafari

Available for [iOS](#) and [Android](#). With this app we are well apart from the world of educational apps for kids. SkySafari is so well known among the visual astronomy community that it needs no introduction here. SkySafari features all the basics for the perfect stargazing experience. The app allows the user to simply point their device at the sky and even includes helpful features like voice control, which allows users to easily search for items or select items to be viewed closer.

## Stellarium

One of the oldest and best-known apps on the market. iOS and Android. offers a lot of functionality. It promises to be the most realistic possible view of the skies, showing the scenery above just as you would see them with the naked eye.

## NASA

Although this app is not built for stargazing, the in-depth information from NASA will have users looking to the skies in awe of the wonders of space! This app features the latest images, videos, news and mission information straight from the experts in the field. Perhaps not originally built for stargazing per se, the wealth of information and fascinating facts available on the NASA app will keep your entertained for hours as you learn all about the awe-inspiring world of outer space. This is a go-to for anyone wanting the latest updates, including images, videos, mission information and news straight from the experts as well as exclusive access to a range of quality and engaging content.

## Star Walk

This app provides a practical guide to what is happening all those miles away in real time. Users point their device at the sky and the app opens screens of information about what it is that you are seeing. Adverts are included in the free version, although you can pay £2.99 to enjoy the experience ad-free. Nice-looking reproduction of night sky, with effective MW disc stars & dust lanes. Sour note with Coalsack on wrong side of Crux. Pipe Nebula not shown amid other dark clouds, which do not reproduce real-sky all that closely. Magellanic don't resemble actual-sky view. Shows satellite positions as 'satellite' but does not identify the satellites. Images OK, XMM Newton & HST accurately depicted, if a bit small, but you have to know what they are first. Click on a named star and screen opens with description, e.g. Fomalhaut has good physical, historical, nomenclature, and planetary disc data. HR & HD stars show position, distance, & magnitude. Intriguing planetary tidbits like, 'There's no way you could stand on Neptune without sinking in' and points out that a 100 lb person on Earth would weigh 110 lb on Neptune. Most other measures in metric. Many objects link through to Wiki. Intrusive pop-up ads with noisy videos. When compared with others it is not competitive even at the low price of \$4.99 a year.



## Sky Map

A planetarium app for [Android](#) phone. Use it to identify stars, planets, nebulae and more. Originally developed as Google Sky Map, it has now been donated and open sourced. This app helps you view and locate all the stars, constellations, galaxies, open clusters, planets and much more. You can search for any specific celestial body if you wish to do so. It even works offline. There is even an automatic and manual mode for easy usage. It can be used for an educational purpose or for your leisure hobby. As long as you calibrate as instructed, this app is fantastic. You can search for anything in the sky and it will point you towards it, it names constellations, there are different layers you can choose to have labeled depending on what you're looking for.



## Moon Globe

This one is well worth the price (free). It is a photo-quality map of moon's near side reconstructed from directly over the objects as seen by the Lunar Reconnaissance Orbiter. Excellent images — the crater Plato was shown from above with 5 craterlets visible on the flat floor (more than I see with my 8-inch at 214x). They were detailed enough to see as round objects with raised rims. Since the actual craterlets are 1.5 to 2.2 km in diameter, this is an excellent set of images. Toggle the image and you get named objects in one view and pure image in the other. The moon's dark side shows names but no terrain. No obtrusive ads. A keeper for any



## Astronomy News

This is a free news feed, not an astronomy app, but very useful for the true astronomy follower. Direct-from-the-source astronomy news feed extracted from a variety of respected sources—[space.com](#), [phys.org](#), Science News, Astronomy Magazine (but not Sky & Telescope). The menu also has a list of news feeds from websites like Hubble, ESA, ESO, SETI, exoplanets, on and on. Plus videos from NASA TV and YouTube. I clicked through 10 news blurbs (headline & one sentence) and got the original article on the original publication in 2 screen swipes. Definite keeper if you want up to date on events in the sky.

# How well does your kid's school teach astronomy?

## The world of astronomy applets and simulations

Visualising the intricacies of astronomy equations is difficult for those who do not know what the real-life behaviour of planets, stars, and galaxies is supposed to look like. Since astronomy is not exactly a hasty science, the slow evolution of gradual change in the sky can best be understood if it is speeded up to match our everyday TV, movie, and cellphone experience.

Fortunately for parents and teachers alike, the hard work of creating computer simulations that realistically — and often beautifully — re-create events in the sky has been a long-term goal of numerous organisations around the world.

Today's astronomy-education teacher aids have become so sophisticated that it is easiest for a teacher to show a simulation to their learners before introducing the verbal descriptions and maths. Since astronomy education such a big world, we start with the basics — lesson plans, classroom activities, and the vast body of Applets and simulations.

Listed on the pages below is a get-acquainted sampler of the astonishing variety of educational materials available by simply clicking on a link.

ASSA regional clubs and members can use this list to produce their own club astronomy seminars and classes. Or, interested ASSA members can meet with the principles of their schools to introduce teachers and administrators to the excellent body of course and lecture materials available absolutely free.

# Section 2 – Astronomy Resources for the ELHI Classroom

The Physics Front teaching aids have all you need to teach astronomy

## Lesson Plans:

### Interactive Classroom Materials for Introductory Astronomy

Impressive set of modules on astronomy appropriate for the advanced high school level. Interactive web-based concept questions promote active group discussion. Each topic is accompanied by animations and/or simulations. This is a work in progress at the University of Nebraska-Lincoln.

**Level: Grades 9-12**

### Imagine the Universe! Lesson Plans

Ten standards-aligned lesson plans developed for grades 7-12 on space science and the evolution of the universe. Topics include the electromagnetic spectrum, satellite image data analysis, the origin of the elements, supernovae, and gamma-ray bursts. Look for the printable student guides.

**Level: Grades 9-12**

### Orbital Motion

In this activity students will explore orbital shapes and properties.

### ASPIRE Star Life Cycle

A terrific interactive tutorial on the evolution of stars. It integrates activities, graphs, quizzes, and animations to trace a star's life from its protostar infancy, through youth on the Main Sequence, maturity on the Red Giant Branch, retirement on the Horizontal Branch, old age on the Asymptotic Giant Branch, and death as a White Dwarf



The screenshot shows the 'All Modules' page of the ClassAction website. The page is divided into two columns: 'ClassAction Modules' and 'My Modules'. The 'ClassAction Modules' column lists various astronomy topics such as 'Introductory Concepts', 'Basic Motions & Ancient Astronomy', 'Coordinates and Motions', 'Lunar Cycles', 'Renaissance Astronomy', 'Light & Spectra', 'Telescopes and Astronomical Instruments', 'Sun and Solar Energy', 'ISM and Star Formation', 'Stellar Properties', 'Stellar Properties 2', 'Binary and Variable Stars', 'Stellar Evolution', and 'Milky Way Galaxy'. The 'My Modules' column is currently empty, with a 'create new module' link. At the bottom of the page, there are four buttons: 'Animations', 'Images', 'Outlines', and 'Tables'.

Each of these [Univ. of Nebraska \(USA\) Class Activity Modules](#) leads to a series of web pages with lessons, applets, and reference links to other websites. While notable in their own right, the Univ. of Nebraska is just one of many similar web sites for educators that are presented in the following pages.

## [Nebraska Astronomy Applet Project: Solar System Models Lab \[see right\]](#)

Explore both the Ptolemaic (geocentric) and Copernican (heliocentric) models of the solar system in this module that features two simulations, comprehensive student guide, pre-test, post-test, and content support for teachers.

**Level: Grades 9-12**

## [Nebraska Astronomy Applet Project: Basic Coordinates and Seasons Lab](#)

In this module, you'll find simulations for introducing terrestrial coordinates (latitude/longitude), celestial equatorial coordinates, and how Earth's seasons are related to its axial tilt. It will help build a foundation for understanding obliquity, the angle between an object's rotational axis and a line perpendicular to its orbital plane. Knowledge of obliquity is crucial for astronomy calculations and Earth-based observation. Includes detailed student guide, assessment materials, and background information.

**Level: Grades 9-12.**

## [NASA Jet Propulsion Lab: Eyes on the Solar System](#)

Here you'll find a rich array of visualisation tools for a 3D exploration of our cosmic neighbourhood. The website uses actual data and images generated from past and present space missions. Students can zoom, change lighting, "ride-on-board", do scale comparisons, and replay events in real or accelerated time. Adaptable for a range of grade bands and ability levels.

**Level: Grades 9-12.**

The screenshot shows the 'Ptolemaic System Simulator' interface. At the top, it says 'Astronomy Education at the University of Nebraska-Lincoln' with navigation links: Home, ClassAction, NAAP Labs, Interactives, Video, Mobile, Downloads, Local, More, and Contact. Below this is a breadcrumb trail: Home > NAAP Labs > Solar System Models > Ptolemaic System Simulator. The main area is titled 'Ptolemaic System Simulator' and contains an 'Orbit View' window. This window shows a geocentric model with Earth at the center, surrounded by concentric circles representing orbits for various planets. The zodiac signs are labeled around the perimeter: Cancer, Gemini, Leo, Taurus, Virgo, Aries, Libra, Pisces, Scorpius, and Aquarius. A 'Memory' box with 'store' and 'recall' buttons is in the top right of the orbit view. To the right of the orbit view is a 'Planetary Parameters' panel for Mars, with sliders for epicycle size (0.66), eccentricity (0.10), motion rate (0.52), and apogee angle (106.7). It also has a 'planet type' selector with radio buttons for 'superior' and 'inferior'. Below this is a 'Controls and Settings' panel with a 'start animation' button, an 'animation rate' slider, and checkboxes for 'show deferent', 'show planet vector', 'show epicycle', 'show equant vector', 'show earth-sun line', and 'show epicycle-planet line'. There is also a 'path duration' slider. At the bottom of the orbit view is a 'Zodiac Strip' showing the signs from Pisces to Aries. A 'Key' section at the bottom right explains the symbols: a blue dot for Earth, a red dot for the Sun, a yellow dot for the planet, a purple dot for the epicycle, and a green cross for the Earth's position. A note states: 'The earth. In Ptolemy's model the earth is stationary at the center.'

This [University of Nebraska applet of the Ptolemaic System](#) is just one example of the Astronomy Education Department's remarkable array of easy-to-learn applets and simulations for students of all ages. Their website is worth an extended try-it-yourself visit. Best of all, every sim is free.

## Spectra

Easy-to-navigate reference material that explains how astronomers use spectra to understand star composition, structure, and evolution. Contains multiple drawings and photos.

## NASA: Solar System Exploration

Beautifully organised website offers a wealth of information about the objects in our solar system, recent technology used to explore these worlds, space missions, and stories about the people behind the missions. Browse image galleries, explore multimedia resources, find lesson plans, or download videos and animations. Look under the sections on "Missions" and "Technology" for materials designed for high school learners.

**Level: Grades 9–12.**

## Black Holes - An Introductory Resource List

A well-constructed guide to non-technical books, articles, and web sites about black holes. Don't miss the sections on the large black hole at the centre of the Milky Way and links to animations that model the black hole phenomenon.

**Level: Grades 8–12.**

# Content Support For Teachers

## Kepler and His Laws (see sample image right)

This set of materials pertaining to Kepler's laws includes equations and properties of conic sections, scale of the solar system, the energy equation for Keplerian motion, and Newton's "Universal Gravitation". It is part of a larger collection that offers lesson plans, lecture materials, and historical background.

## Student Tutorials:

### Interactive Classroom Materials for Introductory Astronomy

Impressive set of modules on astronomy appropriate for the advanced high school level. Interactive web-based concept questions promote active group discussion. Each topic is accompanied by animations and/or simulations. This is part of the University of Nebraska-Lincoln interactive GIF series.

**Right:** Page from the section on Johannes Kepler is part of [From Stargazers to Starships](#) by David Stern on the [psys6.org](http://psys6.org) educational materials website.

## Ellipses!

The ellipse, the shape of a flattened circle, was well known to the ancient Greeks. It belonged to the family of "conic sections," of curves produced by the intersections of a plane and a cone.

As the drawing above on the left shows, when that plane is...

--perpendicular to the axis of the cone, the result is a **circle**.

--moderately inclined, an **ellipse**.

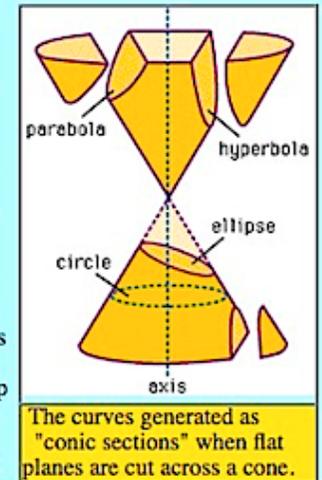
--inclined so much that it is parallel to one side of the cone, a **parabola**.

--inclined even more, a **hyperbola**.

(and when the plane includes the tip of the cone, it becomes two intersecting straight lines. That is the shape of a hyperbola under extreme magnification, when its curving tip becomes insignificantly small.)

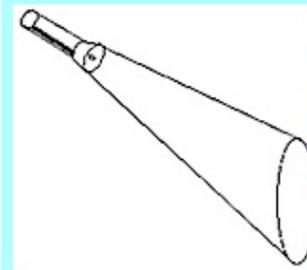
All these intersections are easily produced by a flashlight in a moderately dark room (**drawing below**). The flashlight creates a cone of light and when that cone hits a wall, the shape produced is a conic section--the intersection of the cone of light with the flat wall.

The axis of the flashlight is also the axis of the cone of light. Aim the beam perpendicular to the wall to get a **circle** of light. Slant the beam: an **ellipse**. Slant further, to where the closing point of the ellipse is very, very far: a **parabola**. Slant even more, to where the two edges of the patch of light not only fail to meet again, but seem to head in completely different directions: a **hyperbola**.



The curves generated as "conic sections" when flat planes are cut across a cone.

## The Third Law



After Tycho's death, Kepler became the court astronomer, although the superstitious emperor was more interested in astrology than in the structure of the solar system. In 1619 Kepler published his **third law**: the **square of the orbital period  $T$**  is proportional to the **cube of the mean distance  $a$**  from the Sun (half the sum of greatest and smallest distances). In formula form

$$T^2 = k a^3$$

with  $k$  some constant number, the same for all planets. Suppose we measure orbital periods in **years** and all distances in "**astronomical units**" or **AUs**, with 1 AU the mean distance between the Earth and the Sun. Then if  $a = 1$  AU,  $T$  is one year, and  $k$  with these units just equals 1, i.e.  $T^2 = a^3$ . Applying now the formula to any other planet, if  $T$  is known from the observations of many years, the planet's  $a$ , its mean distance from the Sun, is readily derived.



# Basics of Radio Astronomy

Jet Propulsion Laboratory  
California Institute of Technology

## Basics of Radio Astronomy [see splash page left]

This tutorial, sponsored by NASA's Jet Propulsion Laboratory, is a cost free online workbook/tutorial on the fundamentals of radio astronomy. It would be appropriate to augment a unit on electromagnetic radiation, and includes a unit exam. Available as a downloadable PDF.

## Field-Tested Learning Assessment Guide

This is an assessment guide for STEM instructors. Learn about research-based assessment design and view examples of varied classroom assessment techniques (CAT's). Diagnostic pre-tests are included for both astronomy and physics learners.

## Mass - Comparing Masses Without Use of Gravity

How to measure mass in a weightless environment

This Nebraska Astronomy Applet module introduces the search for planets outside of our solar system using the radial velocity and transit methods. Planets around other stars proved very elusive to find until 1995, when astronomers in Geneva detected an exoplanet using the radial velocity (or Doppler) technique. Since that time, hundreds of exoplanets have been discovered in this manner. The transit method, used in the Kepler Mission is explained in this module.

**Level: Grades 9-12**

## Activities:

### StarDate Classroom Activities

A collection of standards-based lesson plans for K-12 developed to help teachers integrate astronomy into the physical science classroom.

**Level: Grades K-12**

### Double Vision: How we learned the distance to the stars

Using the parallax method to calculate astronomical distances.

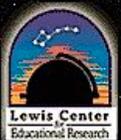
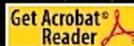


This workbook, although applicable to all radio astronomy, was developed to support training for the Goldstone-Apple Valley Radio Telescope.

What is the Goldstone-Apple Valley Radio Telescope?

What's the purpose of this "workbook"?

**Download Basics of Radio Astronomy (.pdf)**



This workbook was prepared by  
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Published by  
Jet Propulsion Laboratory  
Mission Execution and Automation Section  
Customer Integration Services Group

Document No. JPL D-13835

# Astronomy applets and simulations

## Folding Paper Model of the Magnetosphere

This website provides instructions and an image which can be downloaded, printed on a regular page, copied by a xerox machine (preferably, onto stiff paper), cut and folded to produce [a model of the Earth's magnetosphere](#). A supplement to "Exploration of the Earth's Magnetosphere" whose index page is linked at the beginning and the end of the above page. [See this page for simple step-by-step instructions.](#)

## Astronomy and Physics Simulations from [www.astronomycenter.org](http://www.astronomycenter.org)

This collection of animations and simulations illustrate galaxy collisions, fusion in the sun, the Big Bang, the inverse square law, searching for black holes, the H-R diagram, eclipsing binary stars, proper motion, parallax, the Doppler Effect, blackbody radiation, and Solar System exploration.

**Level: Grades 11–12 & undergrad.**

## The University of St. Andrews in Scotland

has produced an exceptionally comprehensive [Guide for Astronomical Learning and Teaching Resources](#) database covering class lecture plans, websites, and software / app resources for teachers from **K–12 to varsity.**

## Concordia University in Oregon, USA

offers a list of weblinks to databases, books, and reference materials for the study of physics and astronomy in [Physics & Astronomy: Physics Simulations](#). Each of the many icons can be copied as an image for reproduction on paper, or linked through to full-motion applets for emailed or online lesson plans. You can have fun for hours playing with the 49 clickable applets, even if they are targeted for **K–12 teachers.**

Visualising the intricacies of astronomy equations is difficult or many people, not least of which are young students unfamiliar with what the real-life behaviours or planets, stars, and galaxies is supposed to look like. Fortunately for parents and teachers, the hard work of creating computer simulations has been an ongoing effort by numerous organisations around the world. The sims have become so sophisticated that it is easier to run a simulation to a student or class before translating backwards into the maths and verbal descriptions.

## University of Colorado PhET simulations

### PhET Interactive Simulations

are an amazing assemblage of over 100 applets and sims depicting motion, sound and waves behaviour, work-energy-power, heat & thermodynamics, quantum phenomenon, light & radiation, and electrical circuits & magnetism. Let your kids loose on this and there will be peace and quiet in the house for hours.

### A Physics Applet to demonstrate: Kepler's Second Law

The world of [applets designed to visually depict astronomical properties](#) is a very large one. These Java applets model the motion of planets using Kepler's Second Law. The time taken to sweep out equal areas on opposite sides of the orbit is shown. The semi-major axis and eccentricity of the orbit can be changed. There is also an option to show the velocity vector of the orbiting object. This is available in a different languages and is part of a large collection of similar physics applets.

When you've tried all these and everything else, too, go to [Physics Applets to Demonstrate Astronomy](#) and see what you missed.

# Star Life Cycle

Although stars may seem like permanent fixtures in the sky, they are actually very dynamic objects. Stars grow old and die, while new stars are being formed all throughout the universe.

This lesson is designed to help you learn about this process. It will discuss where stars come from, how they form, what keeps them going and what happens to them after they die. It will also show how the birth and death of stars is responsible for creating most of the elements that make up the earth and the rest of the universe.

The lesson is divided up into five sections, each one discussing a particular topic in astrophysics or a specific period in a star's life cycle.



 <b>Studying Stars</b>	Learn about how astronomers study the stars and how things like light and color allow them to understand the way stars develop.
 <b>Protostars</b>	Find out where stars come from and what factors determine the kind of star they turn into.
 <b>Main Sequence</b>	Learn more about the longest phase of a star's life and about the reactions that keep stars burning for millions of years.
 <b>Old Stars</b>	Find out about all the different things that can happen to a star as it begins to grow old.
 <b>Stellar Remnants</b>	Discover what happens to a star after it dies. Many of the most mysterious objects in the universe are not true stars, but the remains of stars that have long since died.

In addition to the main lesson, further information and definitions of key terms can be found in the appendix section.

## Appendix

- Glossary
- Advanced Fusion
- Image Terms of Use

## [StarChild: A Learning Center for Young Astronomers](#)

StarChild is an online astronomy learning centre for elementary and middle school students. Included are materials about the solar system, the Milky Way galaxy, and extra-galactic astronomy. Materials are divided into two different grade levels **K-8 and high school physical science**.

## [Where Is Polaris?](#)

The University of Chicago Digital Library Development Centre teamed with the Adler Planetarium & Astronomy Museum to produce this interactive tutorial that shows why Earth's rotation makes it appear that stars are orbiting the Earth. The simulation features Polaris (the North Star) as its focal point to show that stars are fixed in their positions -- it's the Earth which is moving as it rotates on its axis, offering hour-by-hour views of the sky on a clear night from both reference points.

## [Nebraska Astronomy Applet Project: Extrasolar Planets Lab](#)

The NAAP Extrasolar Planets Lab introduces the search for planets outside of our solar system using the Doppler and transit methods. It includes simulations of the observed radial velocities of singular planetary systems and introduces the concept of noise and detection. The two applets on the website, the *Exoplanet Radial Velocity Simulator* [swf] and *Exoplanet Transit Simulator* [swf] explain centre of mass, Doppler shifting, object detection, and object simulation. Both simulations require Adobe Flash.

## [Online educational resources for Physics teachers](#)

This is an extensive list of web-based resources for teaching physics and math. Its target student levels are upper high-school and undergraduate. Many links are to collections of resources, many simulations or animations of concepts. *Reference material is also included.* (A few of the links are no longer active.)

# Astronomy education material for K-12 (pre-school to honours level)

## ASPIRE (Astrophysics Science Project Integrating Research and Education) lesson plans [see image to right]

This comprehensive web site of lessons, tutorials, and teacher assessment tools includes free access to interactive science labs with downloadable simulations. Half of the simulations are related to Astronomy and half pertain to general topics such as simple machines, force, motion, momentum, and kinetic energy. Each interactive lab is designed to be visually attractive and fun, yet mentally challenging for students in the middle grades. Materials include complete lesson plans which were authored collaboratively by teachers and research scientists.

**Level: Grades 4–9.**

## Activities:

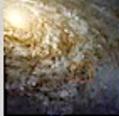
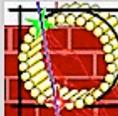
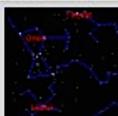
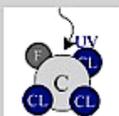
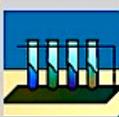
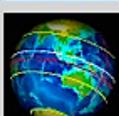
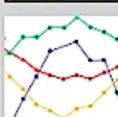
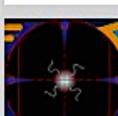
### Kepler: A Search for Habitable Planets.

NASA's Kepler Mission was launched in 2009 with the focused goal of surveying regions of the Milky Way Galaxy to discover Earth-size planets. The spacecraft's detection instrument is a photometer that continually monitors 145,000 stars to locate exoplanets in the "habitable zone" of a star, where liquid water and possibly life might exist. The website tracks information about mission results, with more than 2,000 candidates identified after the first year's operation. Of those, two Earth-size candidates have been confirmed as of January, 2012. Educators will also find classroom activities, interactive resources, simple animations showing how the detection system works, and galleries of photos, videos and 3D images.

[Ed. note: The Kepler Mission employed the Transit Method of exoplanet detection.

**[See here for an animation that will help students understand the Transit](#)**

Right: [ASPIRE Lesson Plans](#) (most include applets or sims) & some require Flash.

LESSONS			
	<b>Bread Board</b> <i>A project teaching basic electronics, programming and concepts about persistence of vision.</i>		<b>Cosmic Zoom</b> <i>Zoom in from the far reaches of the galaxy by powers of ten.</i>
	<b>Force and Motion</b> <i>Learn about the effect of force on velocity and motion.</i>		<b>Gas Particles in Motion</b> <i>Learn about the relationships between volume, temperature, and pressure.</i>
	<b>In Search of Cosmic Rays</b> <i>Learn about how scientists search for Cosmic Rays.</i>		<b>Kinetic Energy</b> <i>Learn about the relationships between mass, speed, and energy.</i>
	<b>Lunar Phases</b> <i>Learn about the lunar phases.</i>		<b>Machines</b> <i>Learn about simple and complex machines!</i>
	<b>Night Sky Viewer</b> <i>See the night sky anywhere on Earth!</i>		<b>Our Atmosphere</b> <i>Learn about the atmosphere.</i>
	<b>Refraction Demos</b> <i>Learn about how light refracts through prisms and raindrops.</i>		<b>Scientific Method</b> <i>The scientific method and its application to astronomy.</i>
	<b>Scientific Notation</b> <i>Learning to use large numbers.</i>		<b>Seasons Activity</b> <i>Use a sundial to observe seasonal changes.</i>
	<b>Seasons Exercise</b> <i>Use seasons to determine your location.</i>		<b>Seismic Waves</b> <i>How do scientists know what the core of the Earth looks like? Learn more about seismic waves and find out.</i>
	<b>Shoot the Stars</b> <i>Use the Doppler effect in this virtual lab to learn if a star is moving toward or away from Earth.</i>		<b>Star Life Cycle</b> <i>Learn the full life cycle of a star.</i>
	<b>Sun Angle</b> <i>Why doesn't it get warm at the North Pole like it does at the equator, even though it has 24-hour days?</i>		<b>Tides</b> <i>Learn about the Earth's tides.</i>

# IMAGINE THE UNIVERSE!

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- ★ NCTM & NSES Standards
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Astronomer's Toolbox

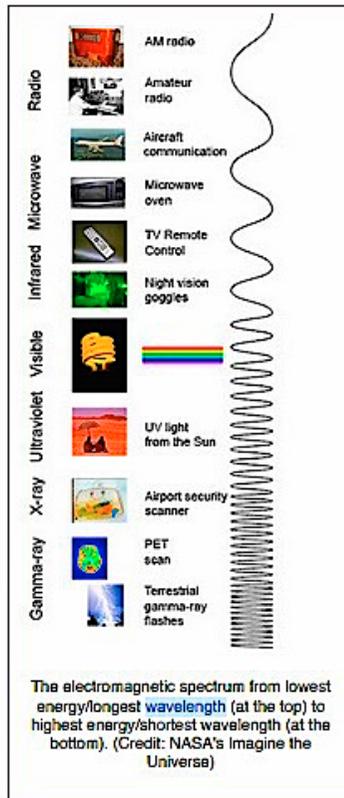
Search

Basic Advanced

## The Electromagnetic Spectrum

The electromagnetic (EM) [spectrum](#) is the range of all types of [EM radiation](#). Radiation is energy that travels and spreads out as it goes – the [visible light](#) that comes from a lamp in your house and the [radio](#) waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are [microwaves](#), [infrared light](#), [ultraviolet light](#), [X-rays](#) and [gamma-rays](#).

You know more about the electromagnetic spectrum than you may think. The image below shows where you might encounter each portion of the [EM spectrum](#) in your day-to-day life.



**Radio:** Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by [stars](#) and gases in space.

**Microwave:** Microwave radiation will cook your popcorn in just a few minutes, but is also used by [astronomers](#) to learn about the structure of nearby [galaxies](#).

**Infrared:** Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the [dust](#) between stars.

**Visible:** Our eyes detect visible [light](#). Fireflies, light bulbs, and stars all emit visible light.

**Ultraviolet:** Ultraviolet radiation is emitted by the Sun and are the reason skin tans and burns. "Hot" objects in space emit UV radiation as well.

**X-ray:** A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag. Hot gases in the [Universe](#) also emit X-rays.

**Gamma ray:** Doctors use gamma-ray imaging to see inside your body. The biggest gamma-ray generator of all is the Universe.

## Exoplanet Exploration: Planets Beyond Our Solar System

This website is dedicated to keeping the public updated and informed about the recent discoveries of exoplanets. This website provides information on NASA's missions, the technology used to detect exoplanets, the history of discovering exoplanets, how planets and solar systems form, and the people and projects involved in discovering other planets. There are activities, animations, and a photo gallery for educators.

**Level: High school to undergraduate.**

## NASA Jet Propulsion Lab: Eyes on the Solar System

Here you'll find a rich array of visualisation tools for a 3D exploration of our cosmic neighbourhood. The website uses actual data and images generated from past and present space missions. Students can zoom, change lighting, "ride-on-board", do scale comparisons, and replay events in real or accelerated time.

**Adaptable for a broad range of grade bands and ability level, generally grades 3–12.**

## NASA: Solar System Exploration

NASA's Solar System Exploration website offers a wealth of information about the objects in our solar system, recent technology used to explore these worlds, space missions, and stories about the people behind the missions. Users will find image galleries, multimedia resources for teachers and learners, videos, animations, and other interactive features to explore the planets, comets, asteroids, the history of robotic exploration, and future missions. **Level: K–12.**

## Imagine the Universe (see sample page left)

This comprehensive NASA website, intended for adolescent learners, provides timely news and information about space exploration and space science. Included are many creative resources, such as "[Ask an Astrophysicist](#)", "[What does the astrophysicist do?](#)", "[Satellite Showcase](#)", and "[High-Energy X-ray and gamma ray observatories](#)".

# The complete range of Physics Front teaching aids & tools can be perused here.



## Editor selections by Topic and Unit

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### Modern Physics

[Atomic Physics](#), [Biophysics](#), [Condensed Matter](#), [Elementary Particles](#), [General](#), [Medical Physics](#), [Nanoscience](#), [Nuclear Physics](#), [Plasma Physics](#)

### Oscillations & Waves

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### Quantum Physics

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### Thermo & Stat Mech

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### Fluid Mechanics

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### Mathematical Tools

[Algebra](#), [Trig and Pre-cal](#), [Vector Algebra](#), [Calculus](#), [Complex Variables](#), [Coordinate Systems](#), [Differential Equations](#), [Linear Algebra and Tensors](#), [Series and Functions](#), [Probability](#), [Statistics](#)

### Optics

[Color](#), [Diffraction](#), [General](#), [Geometrical Optics](#), [Interference](#), [Modern Optics](#), [Photometry](#), [Polarization](#), [The Eye](#)

### Other Sciences

[Chemistry](#), [Computer Science](#), [Engineering](#), [Environmental Science](#), [Geoscience](#), [Life Sciences](#), [Mathematics](#), [Meteorology](#), [None](#)

### Relativity

[Galilean Relativity](#), [Special Relativity](#), [General Relativity](#), [Reference Frames](#), [Spacetime Fundamentals](#), [History](#), [Beyond Relativity](#), [Miscellaneous](#)



# Section 3 – Downloadable Astronomy Catalogues

## Catalogs of Catalogues

SEDS *List of Common Deep Sky Catalogs* (many links)  
Deep Sky Catalogues, last edited Sept 2015 by SkyNomad  
Danilo Pivato, *List of Astronomical Catalogues - Nomenclature, Acronyms & Abbreviations* (last update Apr 2016)

## Observing Guides

### ASSA Top 100 Observing List

Alvin Huey's *Downloadable Observing Guides*  
Alvin Huey's *Printed Observing Guides* (spiral or coil bound)  
Alvin Huey, *Herschel 400 Observing Guide I* (downloadable PDF)  
Alvin Huey, *Herschel 400 Observing Guide II* (downloadable PDF)  
Alvin Huey, *Herschel 300 Observing Guide III* (downloadable PDF)

## Sharpless emission nebulae & SNRs

Stewart Sharpless, *A Catalogue of H II Regions*, 1959.  
*Life & Work of Stuart Sharpless*  
*Sharpless Catalogue by Reiner Vogel*, fully illustrated with positions  
& observing notes.  
Dean Salman's *Best of the Sharpless Catalogues*.

## Young Stellar Objects (YSOs) and Herbig-Haro Objects

*Rainer Vogel* Hubble's Variable Nebula and NGHC 1999 Orion.

## Dark Nebulae & Barnard Objects

Edward Emerson Barnard, *A Photographic Atlas of Selected Regions of the Milky Way*, Carnegie Institution of Washington, 1927 (lists citations only, see *A-J 41, I-24 1919* and *Mikkel Steine's messier45.com* for versions with images and text).

## Galactic Cirrus & Integrated Flux Nebulae

Steve Mandel, *Unexplored Nebulae Project*  
Lynds *Catalogue of Dark Nebulae*, *Astrophysical Journal Supplement*, vol. 7, p.1, 1962. Beverly Lynds' list of 1802 dark nebulae N of  $-33^\circ$  compiled from the National Geographic-Palomar Sky Atlas (POSS).

## Wolf-Rayet expansion shells

Reiner Vogel, *Wolf-Rayet Shells* with analyses by *Lionel Mulato*.  
Agnès Acker, *Nebuluses autour d'étoiles Wolf-Rayet*, *l'Astronomie* 2015.

## NASA Collection of Weird HI Galaxies

Too good to pass up.

## Source Catalogues for the Open Clusters we like most

About 2100 galactic open clusters are known. Most of them have been observed in at least one of the five commonly used photometric systems. The number of stars per cluster ranges from several thousands for the most prominent clusters down to as few as a dozen stars for the poorest clusters.

### *Wiki has a nice list in the 'Best & Brightest' manner.*

It's a crossover list, some GCs are included. Each cluster number has a link to a more detailed Wiki page about the cluster. A good example is *Hodge 301* in the LMC. It is part of the same massive *Tarantula Nebula* star-forming complex but is offset several arc minutes from the super-massive R136 cluster at the heart of the Tarantula.

## The Open Clusters and Galactic Structure catalog

was compiled and then systematised data from numerous other catalogues, particularly the 'Big Four'—proper motion, radial velocity, distance, and age.

### **Bruno Alessi, *Open Clusters and Galactic Structure (Also: 1, 2).***

Alessi succinctly states the case for observing open cluster in the lead-off paragraphs of the website above: 'The open cluster system is of great value for the study of Milky Way dynamics, because they span a relatively wide range of ages, that can be determined with more precision than any other spiral arm tracer. They are the key objects to understand the motion of spiral arms and moving groups of stars, to derive the rotation curve and distinguish between star formation processes.'

## Jack Bennett (1960s), *Bennett Catalogue*

Although christened John Caister Bennett, he was known to all as Jack. His modest list of 85 cometary imposters was born in the spirit of Charles Messier. He pounced on an amazing array of objects given that his primary telescope was a 5-inch refractor at 21x mounted on a manually driven alt-azimuth mount. With this he discovered the first supernova since the telescope was invented. He was the veritable model of the meticulous log-keeper. He reported having spent 815 hours fighting off dew, mozzies, and bats, all for the sake of fuzzy bits in an eyepiece. As eccentrics go, Jack Bennett was well ahead of his time.

## Berkeley Open Cluster Catalogue

Compiled by Gosta Lyngå 1979, 90 open clusters numbered between 1 and 104, original source: [Alter, G.; Ruprecht, J.; Vanýsek, V.](#) Catalogue of star clusters and associations, Prague, Pub. House of the Czechoslovak Academy of Sciences, 1958. Sydney van den Bergh 2006, [Diameters of Open Star Clusters](#), A-J v131, No.3.

## *Abbe Nicholas Louis de la Caille*

La Caille was the first observer to systematically catalog the entire southern sky. A remarkable achievement in itself, which morphs into an astonishment when we consider his optical aid, a tube about 25 cm long with an objective lens 13 mm in diameter and magnification of 25x. That is only about 4 times the light-gathering power of the naked eye. ASSA's own Auke Slotegraaf laboriously put together a small sampler list available free [here](#) and in spreadsheet form [here](#).

## Caldwell Catalog

109 mostly Northern objects compiled by Patrick Moore as an additional challenge list to the Messier Objects.

## Per Collinder (1931) Catalogue of Open Galactic Clusters

471 clusters listed by 16 classification parameters, with second non-tabular observational and original sources. Source plates were Franklin-Adams (1953).

## Anton Czernik (1966) New Catalog of Clusters

The source paper is an *Acta Astronomica* paper from Czechoslovakia available only in PDF. Czernik's paper gives some source information, but beyond his mention of them as being 'faint' he does not mention why the catalog was prepared. SIMBAD lists the 45 Czernik clusters on an [HTML linked fully researchable database here](#)

## James Dunlop (1826) Catalog of Nebulae and Clusters

Downloadable PDF of the cluster numbers and the Dunlop story [here](#). There's a fine article about the Dunlop clusters by James Cozens, [James Dunlop's Historical Catalog of Nebulae and Clusters](#). This is a long article about the errors and inadequacies of James Dunlop's 1826 catalog. It also reproduces the original catalog. Since many of the object positions were erroneous or the objects averted imagination, the Dunlop Catalog is better seen as a reference tool than a list to chase after.

## Harvard Catalogue

WEBDA lists 6 out of the 21 Harvard open clusters compiled in 1930 by Harlow Shapely. Half of the clusters are not listed in any other prior catalog. Harvard clusters are generally faint and sparse.

## Haffner clusters

are much studied because they are mostly over 1 billion years old and in advanced states of dissolution into the Galactic medium. Rather little is known about their catalog compiler Hubert Haffner. His original paper containing the classifications is in the German-language *Zeitschr. Astrophys.*, 43, 89-94 (1957), 'Neue galaktische Sternhaufen in der südlichen Milchstrasse'. If you are rather more keen on just having a look) at them, [WEBDA](#) lists the positions and data for 23, all of which are faint and rather high in the Galactic plane due to disc heating processes that tend to move old star clusters ever outward into the disc from the centreline where most clusters are born. If you want to know more you can search for individual Haffners by typing the cluster name into the search box on [SIMBAD](#).

## Hogg star clusters

These 23 obscure and rather hard to identify clusters were catalogued by Arthur Hogg during his research into the variable stars in the Large Magellanic Clouds. [WEBDA](#) lists all 23 of them.

## James Kaler, *Open Clusters Visible to the Naked Eye*

(includes three globulars).

## King Star Clusters

[WEBDA](#) lists all 26 of them. King 17, 18, 20, 23, 26 were recently studied for the first time by *A.L. Tadross*.

## Robert Trümpler Classification of Star Clusters

Born in Switzerland, Robert Trümpler emigrated to the United States in 1915. Trümpler used telescopes at the Allegheny (Pennsylvania) and Lick observatories (California) to discover that the brightness of distant open clusters was lower than expected. He suspected this dimming was caused by interstellar dust, even though the chemistry of cosmic dust was not well understood. His 1930 analysis of 334 open star clusters included 37 that were not previously listed at that time. These 37 bear the Trümpler name. Trümpler's [system of classifying star clusters](#) is still used today. For Southern observers, Trumpler 14 in the Carina Nebula is one of the most dazzling in the sky. Appearing very compact, it contains over 2,000 stars weighing about 4,300 M<sub>☉</sub>. Its brightest star [HD 93129AB](#) (the AB means it is a spectroscopic binary) is the most luminous star known in the Milky Way, radiating a fearsome 1.3 million times the luminosity of the Sun from a surface temperature of 53,000 K.

## VdB–Ha Uniform survey of clusters in the Southern Milky Way

Sydney van den Bergh – G.L. Hagen, 1975.

## Globular Cluster Catalogs

Alvin Huey free downloadable PDF [Globular Clusters](#).

The original 13 [Palomar globular clusters](#) were first identified on Palomar Observatory Sky Survey (POSS) plates by George Abell in the 1950s. They got their Palomar name (and soon nicknamed Pal globulars) by Helen Sawyer Hogg. The final two, Pal 14 and Pal 15, were added later.

## Planetary Nebula Catalogs

[The Planetary Nebulae](#) from Jim Kaler's *Stars*.

Reiner Vogel, [Large Planetaries Observing Guide](#).

Reiner Vogel, [Proto PN Observing Guide](#).

Reiner Vogel, [Abell Planetaries Observing Guide](#).

George Abell, description of 86 objects in ApJ 04-1966, [Properties of Some Old Planetary Nebulae](#). See Abell's original 1955 paper [Globular Clusters and Planetary Nebulae Discovered on the National Geographic Society-Palomar Observatory Sky Survey \(POSS\)](#).

George Abell, Publ.Astro.Soc.Pacific 08-1955, [GCs & PNs discovered on POSS plates](#).

## Dwarf Galaxy Catalogs

Alvin Huey free downloadable PDF [The Local Group](#)

Sydney van den Bergh, [Luminosity classifications of dwarf galaxies](#)

## Hickson Galaxy Groups

Paul Hickson, ApJ 04-1982, [Systematic properties of compact groups of galaxies](#).

Paul Hickson, A&A 00-1997, [Compact Groups of Galaxies](#).

Paul Hickson's [webpage](#)

Reiner Vogel, [Hickson Catalog of Compact Groups of Galaxies](#)

Gottlieb & Shields. [32 Interesting Hickson Groups](#).

## Abell Galaxy Clusters

Alvin Huey, [Abell Galaxy Clusters](#) (free downloadable PDF).

## From our colleagues at [IceInSpace](#) in Oz:

**John Bambury** has created his BAM600, a variation on the Herschel 400 compiled especially for southern-skies observers.

**Stephen Saber** has a [list of 110 doubles](#) accessible with a 6-inch.

**Glen Cozens** has a [150 Dunlops list](#).

**Paul Mayo** has a [100 Brightest Galaxies for Southern Observers list](#).

**Ian Cooper** has a wonderful [hirez SMC chart](#) detailed enough to list even the SMC's hardly-ever-observed GC & YMCs cluster L1 & L2 below 47 Tuc and L113 in the middle of the SMC's quadrant..

[Excel spreadsheet of 235 SMC objects](#).

**Patrick Cavanaugh** has an excellent set of [14 LMC and SMC hires photo charts](#) with object IDs, plus another zip file of observing notes.

## The Hertzsprung-Russell Diagram

Jim Kaler's [The Hertzsprung-Russell \(HR\) Diagram](#) opens to a box of 56 rectangles, each of which references a particular topic. Click on any one topic and a main page opens up which discusses all 56 options, showing the specific option you clicked at the top of the screen. (Image at right copied from Kaler source file.)

## A bit more technical . . .

[Openstax.org](#) is a repository of varsity-level textbooks available for free and totally legal under the auspices the [Creative Commons Licence](#). You can even preview them by clicking on a specific title's box. Give their [Astronomy](#) textbook a click.

### Stars

Jim Kaler, [The Natures of the Stars](#)

The [Morgan-Keeler Catalog of 1943](#)

### Spectroscopy

Visual starlight tells us what an object looks like. The object's spectrum tells us what it is—and much, much more. We can deduce what the object has been and will become, and what will be the object's effects on its surroundings.

Spectroscopy is the most demanding of the non-mathematical aspects of astronomy. You can stick your toe in the water with **Richard Walker & Marc Trypsteen's** [Twin Book Project, \*Astronomical Spectroscopy\*](#). It's a beginner's guide for advanced amateurs with a yen for physics.

[Astronomical Spectroscopy](#) (a website of links to numerous other resources)

[The Spectra of Stars on the Hertzsprung-Russell Diagram](#)

### **Kharchenko, *Global Survey of Star Clusters in the Milky Way***

The most complete source of astrophysical data thus far and a substantial improvement over previous catalogs based on Hipparchos & Tycho data. Not for the faint-hearted. Lists 3784 objects surveyed, 3006 confirmed. Individual star data from 2MASS, PPMXL, USNO-B1.0, & ICRS, to  $M_V$  20.0, Padova stellar models w/ $J H K$  isochrone fits. Also lists 142 GCs, 19 moving groups, 21 associations, 221 cluster remnants. Most proper motions in mas/yr.

### **Loden Open Clusters**

WEBDA lists 54 of the over 2300 clusters identified with the Loden name. (Many of these WEBDA don't connect to supporting data. Push the mouse button and hope for the best. And once you do get to a Loden, they are ferociously hard to identify on the basis of photo images — and not a great deal easier at the eyepiece. Loden clusters are for that rare soul, the passionate cluster collector with the patience of a saint, endurance of a tardigrade, and eyes of an owl.

### **Melotte Catalogue of Star Clusters shown on Franklin-Adams Chart Plates**

The English amateur astronomer John Franklin-Adams (1843–1912) created an early photographic atlas of the sky, based on plates taken at Johannesburg, South Africa, and in England, published 1913–1914 by P. J. Melotte. 206 charts  $15^\circ$  square each with stars to  $M_V$  17, covering the entire sky. This list contains both open clusters and globular clusters.

### **J. Ruprecht (1963), *Classification of Open Star Clusters***

(To  $M_V$  20.3 based on the POSS blue plates; images S of  $-12^\circ$  were taken with the 10' f/12 Metcalf refractor. Czech astronomer Jaroslav Ruprecht published a definitive list of OB associations compiled from several observatories, all classified following the Trumpler system; 852 true open clusters with 116 not definitively bound systems.

### **Stock (clusters 1 & 2, 1956), (3 to 23, 1959), (24, 1970)**

In the early 1960s the German astronomer Jürgen Stock was asked by the university of Chicago to test sites in Chile for astronomical telescope suitability. Stock already had published two lists of 23 sparse star clusters he had identified in papers on photographic photometry of open clusters and stars in the North Polar Sequence. His three-years of searching eventuated in today's array of the world's largest astronomical instruments being constructed in Chile. He also discovered *three minor planets now named after him*, (4388) Jurgenstock = 1964 VE = 1982 UA = 1999 LG.

### **Clyde Tombaugh (1938 and 1942)**

While he was using the photographic plates from the 13' Lawrence Lowell astrograph, Tombaugh discovered 5 loose aggregations that were eventually shown to be bound clusters. The modern observer/writer Max Radloff wrote a report on the Tombaugh clusters in the now-defunct Deep Sky Magazine in Dec. 1990/91. There is also a Google Group for the Tombaugh objects.

**Jim Kaler, *Spectra***. The splash screen shows a box with 30 rectangles, each with a property about spectra inside. Click on any box and the page opens to a long list of all 30 topics, with the topic you clicked on at the top of the page.

There is a broad overview of the subject from *Cloudy Nights*, one of the online astro-forums for amateur astronomers.

- **Richard Walker** has produced two superb technical guides:  
*Spectroscopy for Amateur Astronomers* (equipment and methods of spectroscopy)
- *Spectral Atlas for Amateur Astronomers* an illustrated guide to what spectrograms reveal about stars and other objects.

You can resolve individual lines on the NIST *Atomic Spectra Database Lines Form*.

## Radio astronomy

*Beginner's Introduction to Radio Astronomy*

*Society for Amateur Radio Astronomy*

*Amateur Radio Astronomy Projects*

*Galaxy Zoo Forum: Build a Radio Telescope*

*Starter Kit for Amateur Radio Astronomy*

*Mike Brown's Build a Radio Telescope At Home*

*How to Build a Radio Telescope*

*An affordable everyday radio telescope*

*Is It Possible to Build a DIY Radio Telescope?*

*SPIDER 300A - Advanced radio telescope*

*AARL (USA) National Association for Amateur Radio* (mainly HAM enthusiasts, but contains radio astronomy guides, too.)

## RESOURCE GUIDE FOR IMPROVING THE QUALITY OF ASTRONOMY EDUCATION IN SOUTH AFRICA

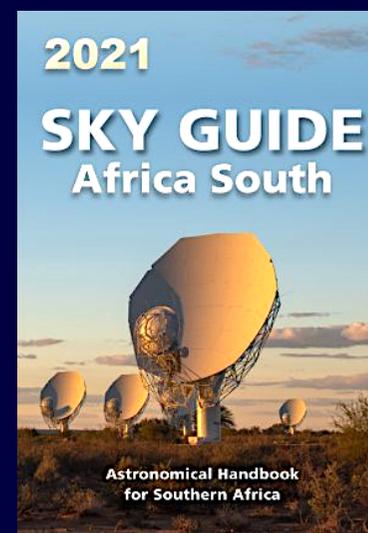
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Printed and bound in South Africa.



ASSA 2021 SKY GUIDE



THE MONTHLY NOTES OF THE ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA

