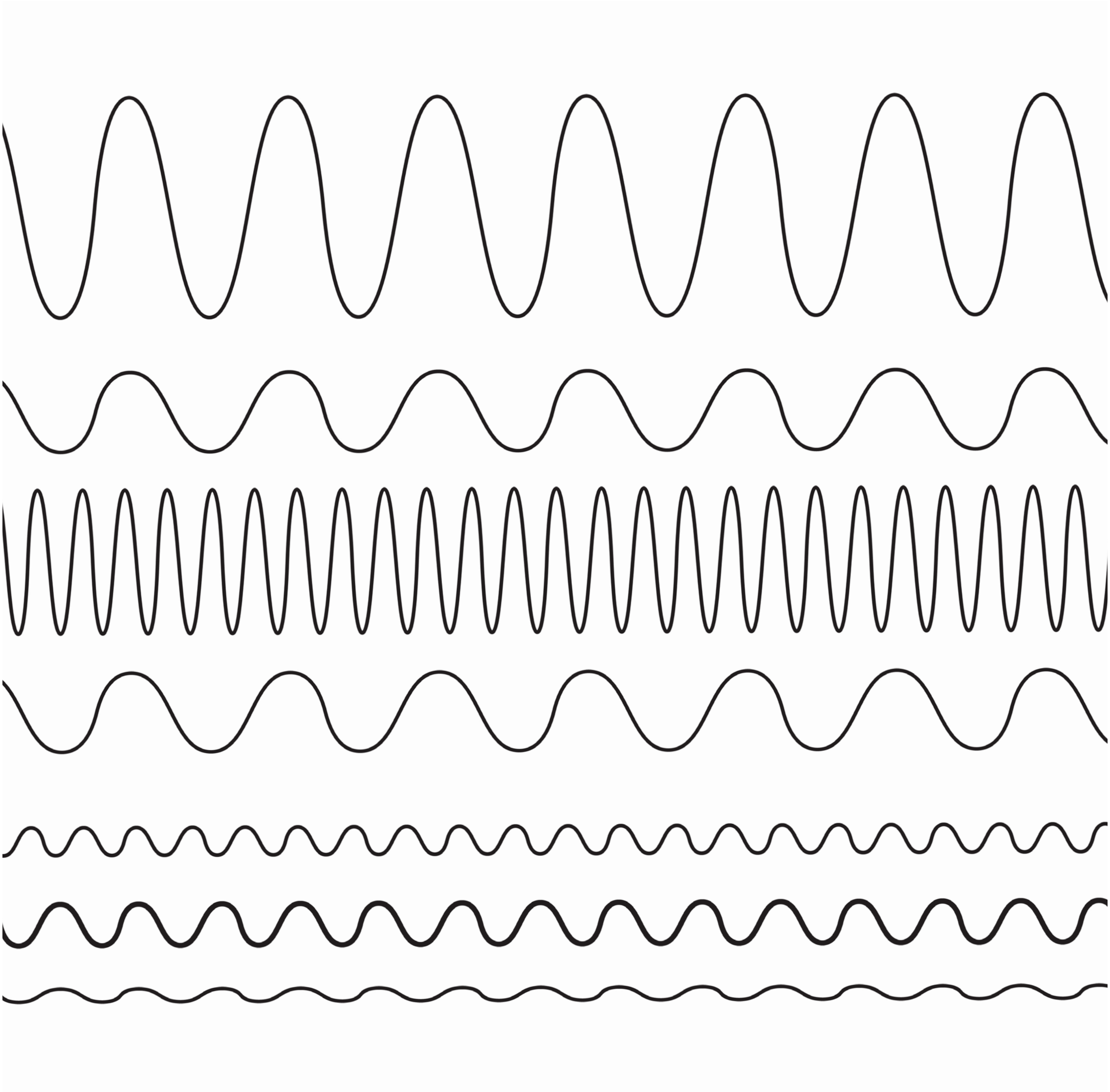


Are You On My Wavelength?

YEAR 9
PHYSICAL SCIENCES

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

QUEENSLAND MUSEUM NETWORK
Queensland Government
THE UNIVERSITY OF QUEENSLAND AUSTRALIA

This teacher resource is produced by Future Makers, a partnership between Queensland Museum Network and Shell's QGC business, with support from the Australian Research Council and other parties to ARC Linkage Project LP160101374: The University of Queensland, Australian Catholic University Limited and Queensland Department of Education.

ENGAGE – EXPLORE – EXPLAIN

Are You on My Wavelength?

Teacher Resource

Electromagnetic radiation is a type of energy that travels in waves. It exists along a spectrum, and can take many different forms depending on its wavelength, frequency and energy. These properties impart different characteristics, which influence their use by people in science and technology, as well as in our daily lives.

In this activity, students explore how electromagnetic radiation is used for different purposes. It is assumed that students have been introduced to the electromagnetic spectrum, electromagnetic radiation, and the properties of different types of electromagnetic radiation, prior to engaging with this activity. Objects from Queensland Museum's Cultures and Histories collection provide context for learning within this activity.

Queensland Museum's Cultures and Histories collection provides a tangible link to human innovation and experience. The collection is comprised of objects that are significant to the people of Queensland, including the material culture of Aboriginal Peoples and Torres Strait Islanders. You can view objects from this collection online and in person at exhibitions on display across the Queensland Museum Network.

Detailed step-by-step instructions can be seen below. It is recommended that you use these instructions to guide your students through the activity. Prior to implementing this activity, we recommend you print out the *Electromagnetic Spectrum Diagram* (see page 6). This diagram can be displayed on the floor or wall. Students should not see this diagram until Step 3.

Following this activity, students have the opportunity to investigate how cultural institutions, including museums, galleries and libraries, use and avoid different types of electromagnetic radiation to conserve their collections. Students will need to conduct online research to complete this activity.

1. Divide students into groups of two or three. Distribute one object image to each group. Ask students to analyse the object using the See-Scan-Analyse strategy:

   See: Describe what you see.

   Scan: Look closely at the object.
   What extra details do you notice now that you didn't before?
   When do you think this object was made?

   Analyse: How do you think this object was used?

   The objects selected for this activity will vary in terms of recognition by students. For differentiation, you may like to provide some students with more recognisable objects (i.e. the television, microscope or some cameras) and other students with less recognisable objects (i.e. the Graflex Series B camera, ophthalmoscope or X-ray tubes).

   Student groups then share their objects and response to the See-Scan-Analyse questions with the class.

2. Inform students that all of the objects have something in common. Provide student groups with time to discuss what this might be, before sharing suggestions with the class. If not already suggested, inform students that all of the objects use electromagnetic radiation to function, and that the frequency at which these objects operate can provide us with more information about how they are used.

   Provide student groups with the frequency at which their object operates (see page 20). Ensure students are aware that objects can operate across a frequency range. For example, although a specific frequency is provided for the mantle clock radio, it is actually able to operate across a range between 535 – 1065 kHz. This is also the case for the television and the X-ray tubes.

   Provide groups with time to convert their given frequency into Hertz (see answers below). You may like to provide students with a conversion table to assist this process (see page 21).

Answers: Frequencies Converted to Hertz

Object		**Frequency**	
Object A	Mantle clock radio	600 kHz ⟶	600,000 Hz 6 x 10^5 Hz
Object B	Television	64.25 MHz ⟶	64,250,000 Hz 64.25 x 10^6 Hz
Object C	Monocular microscope	430–750 THz ⟶	430,000,000,000,000 – 750,000,000,000,000 Hz 4.3 x 10^{14} – 7.5 x 10^{14} Hz
Object D	No. 3A Folding Pocket camera		
Object E	Box camera		
Object F	Graflex Series B camera		
Object G	View camera		
Object H	Kodak Brownie Six-20 camera		
Object I	Trench periscope		
Object J	Opthalmoscope		
Object K	X-ray tube	20 EHz ⟶	20,000,000,000,000,000,000 20 x 10^{18} Hz
Object L	X-ray tube	19.5 EHz ⟶	19,500,000,000,000,000,000 19.5 x 10^{18} Hz

3. Ask groups to move with their object images to the electromagnetic spectrum diagram (see page 6). Ask groups to identify where their object is situated on the electromagnetic spectrum and to place their object at this location. Ask students to consider what they already know about this form of electromagnetic radiation. Pose the following question for students to discuss in their groups: **How does this information change or further inform your thoughts about this object and how it was used?** Student groups then share their responses with the class.

4. Ask students if they are ready to learn more about their objects. Share information about each object (see page 22) with individual student groups. Ask students to comment on this information: **How did your predictions compare and were there any surprises?**

5. Return to the diagram and objects. Inform students that these objects are from Queensland Museum's Cultures and Histories collection. Ask students if they have noticed that some forms of electromagnetic radiation are missing an object (i.e. microwave, infrared, UV and gamma). Ask students to hypothesise why this might be the case. Students may consider both the purpose of a museum and the types of objects that use these forms of electromagnetic radiation in their response.

   Note: Queensland Museum collections are comprised of objects that are significant to the people of Queensland. Items accepted in to the collection must meet significance criteria and support the Museum's strategic themes. They are also assessed for required and/or ongoing conservation work and how much space is needed to store the object.

6. Ask student groups to identify two additional objects that can be added to the diagram. Inform students that each object must use a different form of electromagnetic radiation. Students may conduct research to complete this task, and then present their additions to the class.

7. Following this, students may like to investigate how cultural institutions, including museums, galleries and libraries, use and avoid different types of electromagnetic radiation to conserve their collections.

Curriculum Links

Science

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science as a Human Endeavour

Advances in scientific understanding often rely on technological advances and are often linked to scientific discoveries (ACSHE158)

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Mathematics

YEAR 9

Number and Algebra

Express numbers in scientific notation (ACMNA210)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Numeracy

Estimating and calculating with whole numbers

ICT Capability

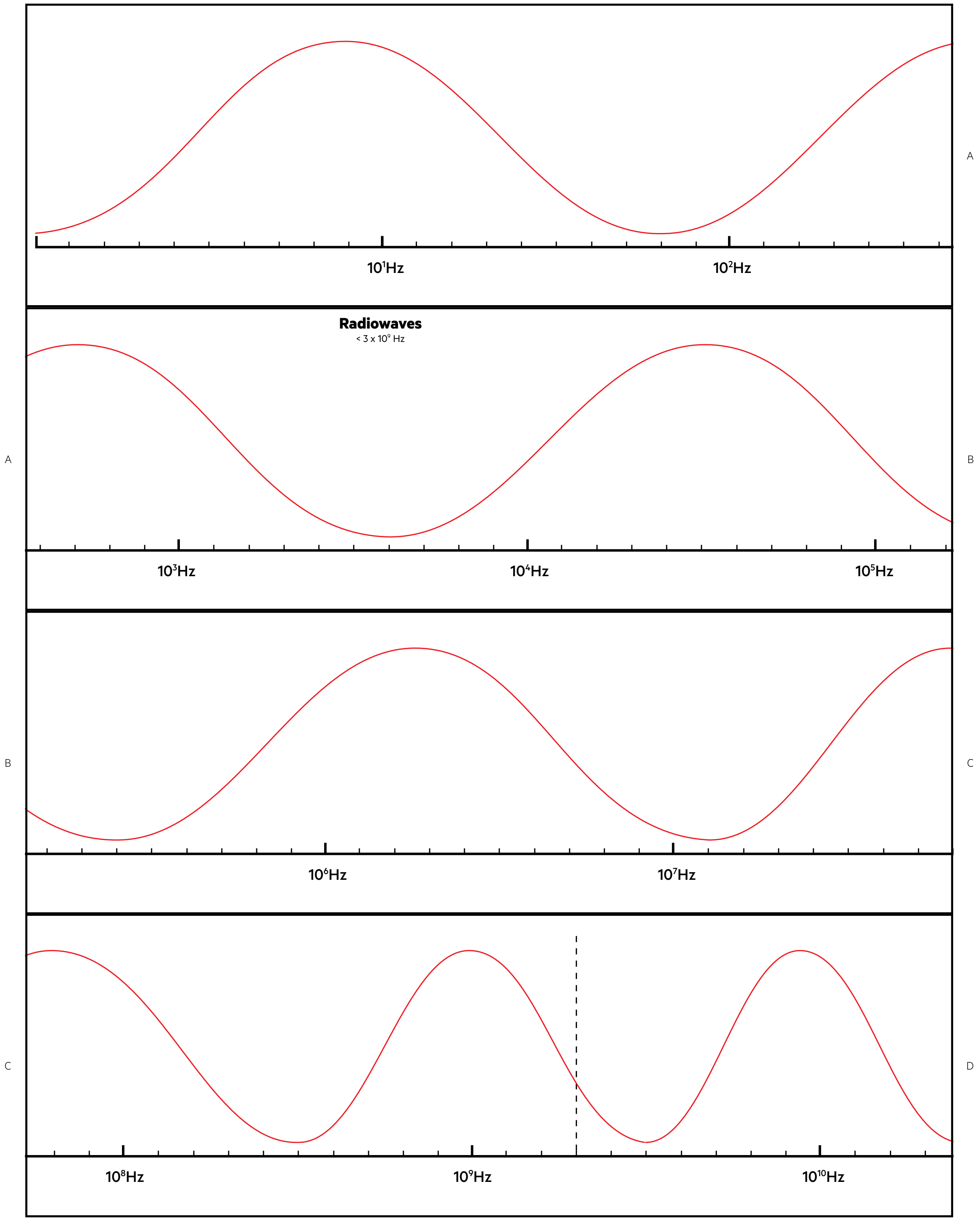
Investigating with ICT

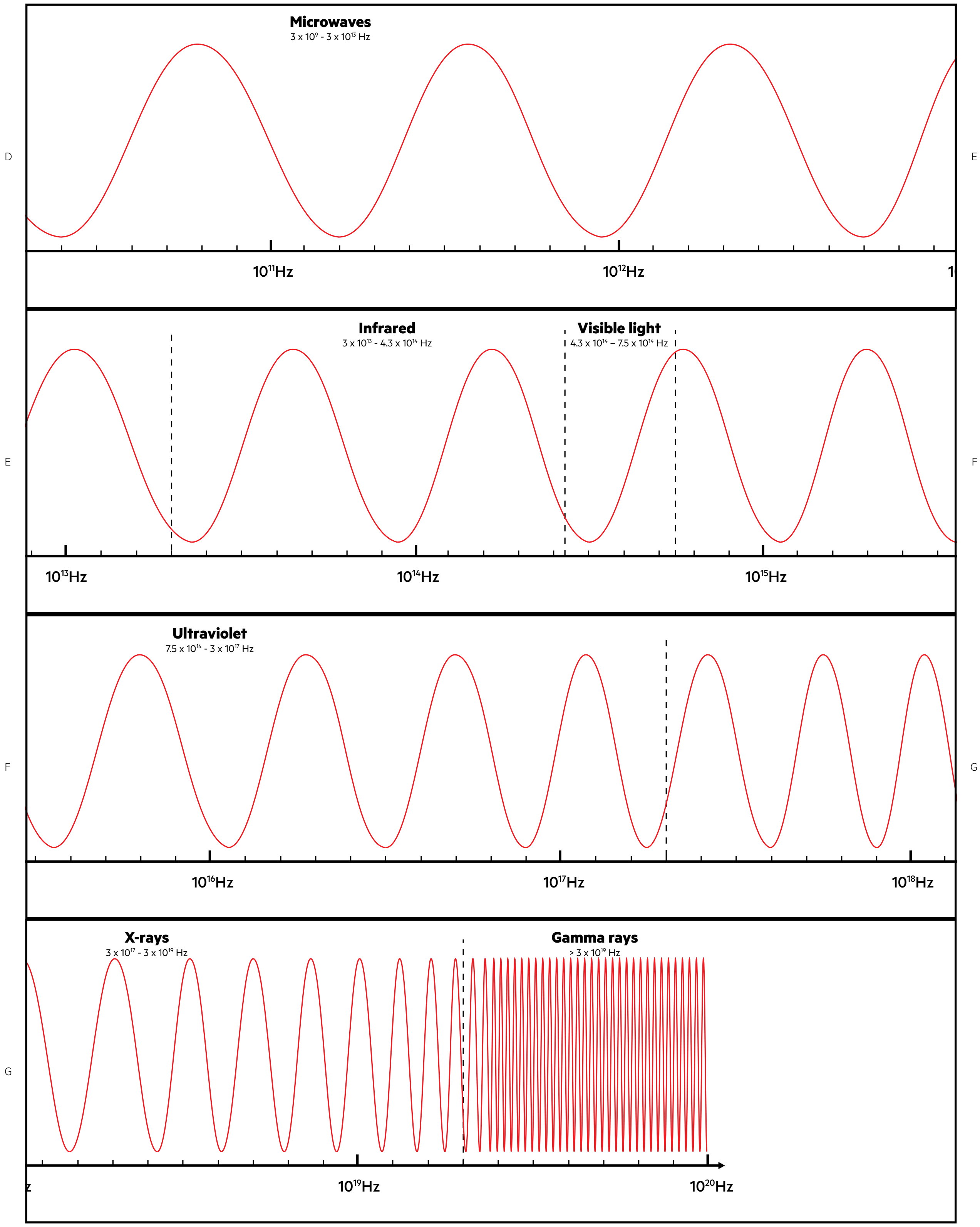
Critical and Creative Thinking

Reflecting on thinking and processes

Electromagnetic Spectrum: Diagram

You can access this resource online at Queensland Museum Network Learning Resources. Search for 'Electromagnetic Spectrum: Diagram'. After downloading the resource, print to A3. Use clear tape or glue to join the sections together.





Microwaves
3×10^{9} - 3×10^{13} Hz
D
E
10^{11}Hz
10^{12}Hz
Infrared
3×10^{13} - 4.3×10^{14} Hz
Visible light
4.3×10^{14} – 7.5×10^{14} Hz
E
F
10^{13}Hz
10^{14}Hz
10^{15}Hz
Ultraviolet
7.5×10^{14} - 3×10^{17} Hz
F
G
10^{16}Hz
10^{17}Hz
10^{18}Hz
X-rays
3×10^{17} - 3×10^{19} Hz
Gamma rays
> 3×10^{19} Hz
G
10^{19}Hz
10^{20}Hz

Object A

Object B

Object C

Object D

Object E

Object F


GRAFLEX-SERIES B
CURTAIN APERTURE
EASTMAN KODAK CO.
FOLMER & SCHWING DEPT.
ROCHESTER, N.Y., U.S.A.

Object G

© Peter Waddington, Queensland Museum

Object H

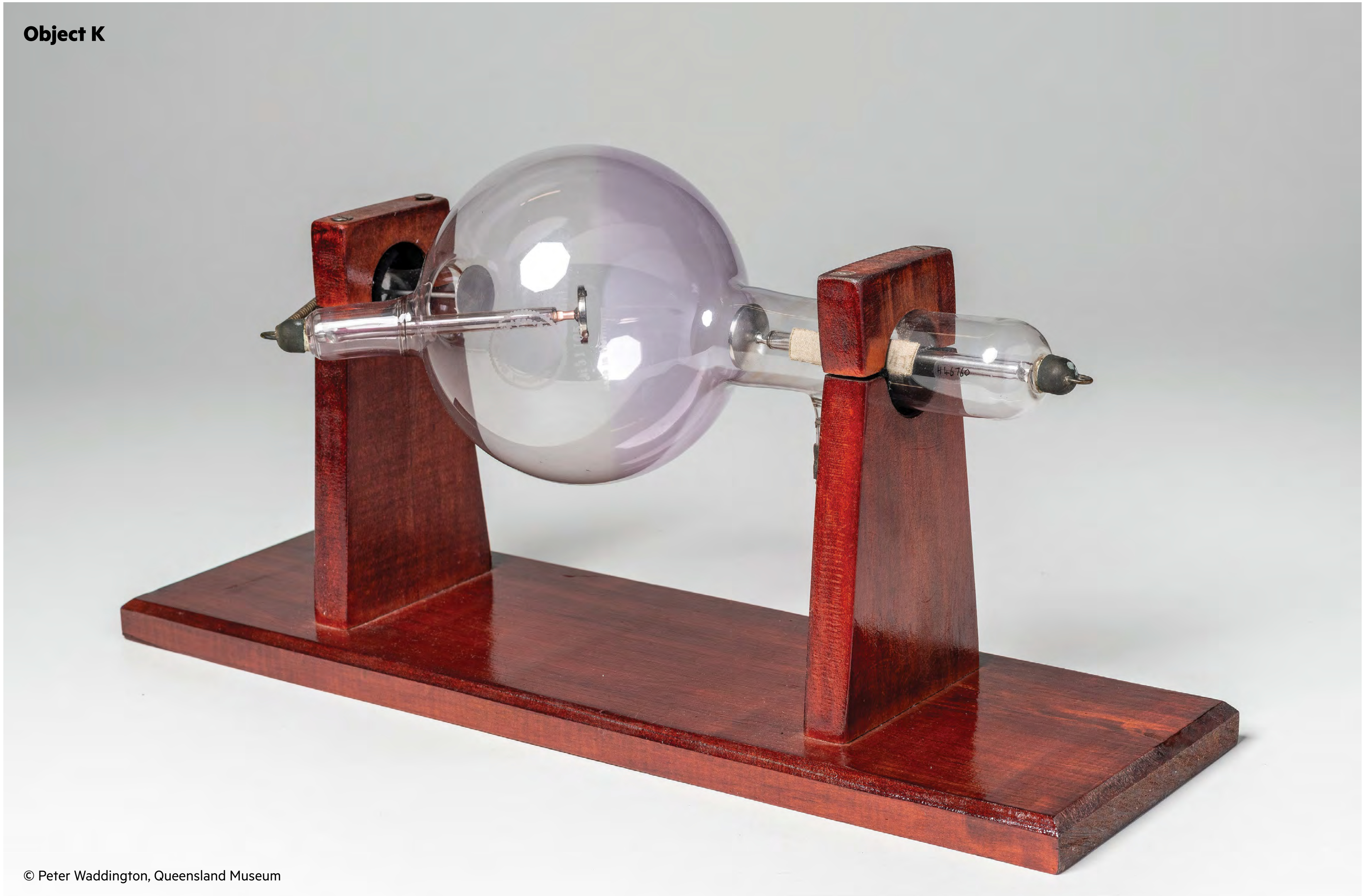
© Peter Waddington, Queensland Museum

Object I

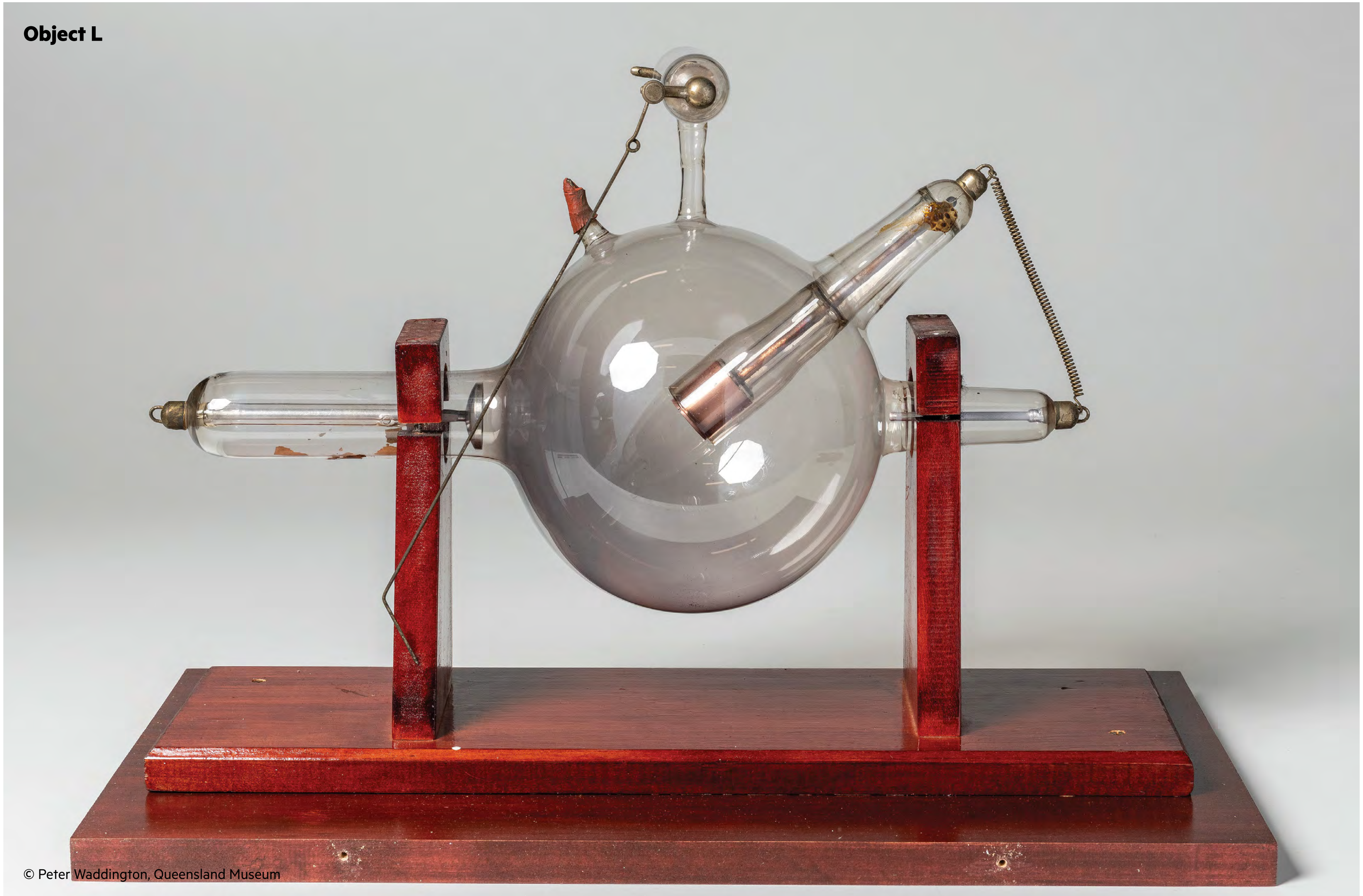
Object J


Inches
Centimetres
KODAK Color Control Patches
Kodak
Blue
Cyan
Green
Yellow
Red
Magenta
White
3/Color
Black

Object K



Object L



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Mystery Objects and Frequencies

Object A 600 kHz	**Object B** 64.25 MHz
Object C 430 – 750 THz	**Object D** 430 – 750 THz
Object E 430 – 750 THz	**Object F** 430 – 750 THz
Object G 430 – 750 THz	**Object H** 430 – 750 THz
Object I 430 – 750 THz	**Object J** 430 – 750 THz
Object K 20 EHz	**Object L** 19.5 EHz

Electromagnetic Wave Frequency Conversion Table

Electromagnetic Wave Frequency	Abbreviation	Equivalent Hertz			
Hertz	Hz				
Kilohertz	kHz	1 kHz	= =	1,000 Hz 1×10^3 Hz	(thousand)
Megahertz	MHz	1 MHz	= =	1,000,000 Hz 1×10^6 Hz	(million)
Gigahertz	GHz	1 GHz	= =	1,000,000,000 Hz 1×10^9 Hz	(billion)
Terahertz	THz	1 THz	= =	1,000,000,000,000 Hz 1×10^{12} Hz	(trillion)
Exahertz	EHz	1 EHz	= =	1,000,000,000,000,000,000 Hz 1×10^{18} Hz	(quintillion)

Electromagnetic Wave Frequency	Abbreviation	Equivalent Hertz			
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Exahertz	EHz	1 EHz	= =	1,000,000,000,000,000,000 Hz 1×10^{18} Hz	(quintillion)

Mystery Object Information

OBJECT A	
Object	Mantle clock radio
Production Date	Unknown
Materials	Bakelite (plastic), metal
Description	This Mantle radio was manufactured by A.W.A. Radiola. This particular model (Model 469 MA) is a stylish mantle radio with a maroon and cream Bakelite (plastic) housing. The insert features an analogue clock plus radio volume and tuning knobs with a list of AM radio stations. The working clock included in the radio, in addition to the frequency display, made it truly a "clock" radio.

OBJECT B	
Object	Television
Production Date	1958
Materials	Plastic, metal, glass
Description	This visually interesting black and white Pye-Technico Television was purchased in Sydney in 1958. Manufactured by James N. Kirby Holdings Pty Ltd in Sydney, the use of coloured plastics such as this pink casing for this television was the height of fashion in the 1950s. A speaker grate is cut into the right side of the television, with speaker mesh behind it. Two metal dials are positioned on the front face of the television, with the model name and crest embossed on a metal plate in the centre of the set. An aerial plate is fixed the top right hand side of the television. James N. Kirby Holdings Pty Ltd was established by James Kirby in 1946. Kirby was a well-regarded industrialist and worked on a number of precision engineering projects and recognised the potential market for household consumer goods in post-war Australia.

OBJECT C	
Object	Monocular microscope
Production Date	1940 - 1959
Materials	Glass, metal (including ferrous and non-ferrous)
Description	This black enamelled metal microscope was made in the Munitions Supply Laboratories (M.S.L) in Maribyrnong, Melbourne. M.S.L worked with the Australian Optical Company to manufacture Australian-made optical instruments during and after the Second World War. There was a shortage of optical instruments during and immediately after the war in Australia because most of the major optical manufacturers were German, or international branches of German companies. This created trade complications and it was decided that Australia would increase their research and supply their own instruments for both military and later civilian use. This would also keep Australia in adequate supply in case war was to break out again. The MSL facility in Maribyrnong, also called the Ordnance Factory, remained open and operational after the War and was used to make microscopes such as this monocular model, which was used in the University of Queensland's Zoology department.

OBJECT D	
Object	No. 3A Folding Pocket camera
Production Date	1903 - 1915
Materials	Non-ferrous metal, glass, leather, wood, paper
Description	The camera has a wood and aluminium body and red leather bellows (the pleated expandable part of the camera). The camera opens out onto a metal support system with a metal track. Wood panelling on either side of the metal track slides out to allow for the extension of the bellows. The camera is protected by a brown leather case. This No. 3A Kodak Folding Pocket camera was owned by Captain Leslie Russell Blake, Queensland Geological Survey Geologist. The camera was possibly used by Blake on the 1913-1914 Mawson Expedition to Macquarie Island. Blake, taking leave from the Queensland Geological Survey, worked on the Steam Yacht Aurora as a cartographer and geologist. He mapped the island and conducted a geological survey, collecting samples and descriptions and taking photographs in an unofficial apacity. This model of folding pocket camera was Kodak's first postcard format camera. The roll film allowed for easy negative development and the camera, while it certainly wouldn't fit in a coat pocket, folded down for ease of transport and storage.

OBJECT E	
Object	Box camera
Production Date	1888
Materials	Metal, leather
Description	This is an example of the first Kodak camera. The camera is made from metal and is covered in leather. It has a single lens, with lens cap, at the front and a small circular button on the left hand side. Released in 1888, this simple box camera was easy to operate and sold for $25 which, while still relatively costly at the time, allowed more people than ever to take photographs outside of formal studios. The camera was sold ready loaded with film sufficient or 100 shots. When the film was used, the entire camera was sent to the Kodak factory for processing. New film was then loaded into the camera, which was returned to the customer along with their photographs. The innovation involved in this camera was chiefly in the film. In 1884 George Eastman, founder of Eastman Kodak, developed paper-backed film which was more flexible than glass backing. He then invented roll-holders for film, allowing for easy and ample portable storage. Eastman's aim was "to make the camera as convenient as the pencil".

OBJECT F	
Object	Graflex Series B camera
Production Date	1907 - 1927
Materials	Wood, glass, paper, leather, metal
Description	Staff of the Commonwealth rickly Pear Board used this Graflex single-lens reflex camera in their research to document prickly pear insects potentially useful for the eradication of the plant in Australia. Members of the Prickly Pear Board travelled all over North, South and Central America - wherever the prickly pear grew - and sent back the most effective insect specimens to the central receiving and quarantining station in Sherwood, Brisbane. The Graflex Series B model marks read ‘Eastman Kodak Co’ indicating that the camera was made between 1907 and 1927, so it was most likely in use in the height of the Prickly Pear Board’s research activities.

OBJECT G	
Object	View camera
Production Date	1870 - 1910
Materials	Wood, brass, metals (non-ferrous), indeterminate textiles
Description	This Thornton Pickard 'Imperial Perfecta' field camera has black leather bellows (the pleated expandable part of the camera) and a dove tailed wood case, with brass fittings. The shutter release cable has a metal handle, with rope cover. A small section of the cable has been repaired with leather, hand-sewn together. The camera runs on a monorail with an adjustable winding mechanism to allow for different focal lengths. The whole device folds up and has a leather carry handle. Thornton and Pickard were a Manchester based company that initially focussed on shutter production and then moved into making quality cameras. This camera belonged to Mr Owen Cook, who purchased it from Mr E. E. Farmer from Rockhampton in the 1930s. At the turn of the century, Mr Farmer was an avid photographer in the Rockhampton region and recorded many community moments in the region with his photographs.

OBJECT H	
Object	Kodak Brownie Six-20 camera
Production Date	1937 - 1940
Materials	Leather, nickel (metal plating), steel
Description	This Brownie camera has a black leather covering over a black painted steel body. It has a leather hand strap on one side, a shutter mechanism and a meniscus lens. The front door is hinged with one side attached to the lens and bellows (the pleated expandable part of the camera). As the cover opens, the lens is automatically advanced and the bellows unfolds. To refold the bellows and stow the lens, the mechanism is released with the lock open button. This Kodak Brownie Six-20 belongs to a collection of objects used by Maude Rose "Lores" Bonney (1897–1994), one of the great early Australian airwomen. Bonney was the first Australian woman to gain a commercial pilot licence, the first woman to fly around Australia, the first woman to fly from Australia to England, and the first person – of either gender – to fly solo from Australia to South Africa. This Six-20 Folding Brownie camera was released by Kodak Limited of the United Kingdom in 1937, the year of Bonney's flight to South Africa. It would have been useful for Bonney's travels because it could fold away, occupying less space when not in use.

OBJECT I	
Object	Trench periscope
Production Date	Pre 1916
Materials	Steel, glass
Description	This portable trench periscope consists of two steel backed and framed glass mirrors linked by two steel rods. When disassembled, the rods are stored between the mirrors, the mirrors nest together and the whole object fits into a cloth pouch. This periscope is an example of the simplest type of periscope, comprising of mirrors that allow the observer to see objects at a distance. Periscopes are instruments that are used to view something that is not in a direct line of sight. While the earliest periscopes were used to see over the heads of others at religious festivals, they were later used mainly in warfare. During the First World War they were commonly used by the troops to see around them while remaining behind shelter, thus reducing the risk of being shot. As the name suggests, trench periscopes allowed the troops to see over the walls of their trench while remaining safe from snipers. This trench periscope was owned by First World War veteran John McGuirk.

OBJECT J	
Object	Ophthalmoscope
Production Date	1940s
Materials	Metal, glass
Description	This ophthalmoscope has an ivory painted handle, an on/off swi ch at the top of the handle and an optical attachment clamped to the lamp which has two rotating discs. The posterior disc is connected to a third disc which has numbers on the dial. This ophthalmoscope represents the early designs of electric ophthalmoscopes, which came with their own light source rather than relying on separate light and magnifying devices. The instrument was used by medical practitioners to examine the eye. It was made in the 1940s by Keeler Optical Products, Ltd, a British company who at that time operated out of London and Philadelphia. The object was used in a medical practice on Wickham Terrace in Brisbane.

OBJECT K	
Object	X-ray tube
Production Date	Unknown
Materials	Wood, glass, steel, copper
Description	This X-ray tube consists of a large hand-blown vacuum glass tube, with four protruding glass stems. There are four electrical contacts at various points of the X-ray tube. The tube is firmly mounted on a wooden stand. In 1864, Carl Heinrich Florenz Müller, who was then 19 years old, began a small glass blowing facility in Hamburg, Germany, where he produced mainly artistic glass products, including wine glasses and "Venetian" goblets. Later, he decided to use his experience in glass making to produce other glass products, including Geissler, Hittorf and Crookes gas discharge tubes, and incandescent light bulbs. Shortly after Röntgen's announcement of the discovery of the new X-rays in January 1896, Müller began to play a prominent role in this area; he constructed the first X-ray tube in 1896 and in 1901 was awarded a gold medal for his X-ray tubes by the British Röntgen Society.

OBJECT L	
Object	X-ray tube
Production Date	1898
Materials	Glass, metal, wood
Description	This X-ray tube consists of blown glass tube with anode, anticathode and focus cathode. Electrodes are connected to soldered terminals by wires. This is an extremely rare and fine example of early X-ray technology. The cathode X-ray tube was amongst the first radiological equipment developed. The cathode, being concave, focuses an electron beam to a small spot on the anticathode, where they are absorbed. This excites atoms in the anticathode, which relax by emitting X-ray photons. X-rays emerge from the side of the tube and since they emanate from a small spot on the anticathode, X-ray images are sharp. The glass becomes discoloured due to radiation damage or metal deposits. Tubes of this kind were used in medicine and for further X-ray experimentation.

Are You on My Wavelength?

Student Activity

Electromagnetic Radiation in Museums, Galleries and Libraries

Museums, galleries and libraries use and avoid different types of electromagnetic radiation to conserve their collections. In this activity, you will identify which types of electromagnetic radiation assist with conservation and/or have damaging properties, and explain how these are used or avoided in a cultural heritage setting. Remember to record any sources of information you have referenced on the following page.

Electromagnetic radiation	**Assists with conservation (Y/N)**	**Has damaging properties (Y/N)**	**Explain how it is used and/or avoided**
Radio waves			
Microwaves			
Infrared radiation			

Electromagnetic radiation	Assists with conservation (Y/N)	Has damaging properties (Y/N)	Explain how it is used and/or avoided
Visible light			
Ultraviolet radiation			
X-rays			
Gamma rays			

Sources: