INKPHYSICS FLASHCARDS

Astrophysics

Year 13 · 26 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Angular magnification.

TELESCOPES AND IMAGE FORMATION

CHECK YOURSELF

A telescope has an objective of focal length 900 mm and an eye lens of focal length 15 mm. Jupiter subtends 2.4×10^{-4} rad to the naked eye. Find the magnification and the angle Jupiter subtends through the telescope, and state what normal adjustment means.

Hint: The ratio of focal lengths first; then remember what a telescope multiplies.

TELESCOPES AND IMAGE FORMATION

SPOT THE ERROR

Say what is wrong with this claim:

A good telescope is one with the biggest magnification.

TELESCOPES AND IMAGE FORMATION

EQUATION — NOT ON THE DATA SHEET

Collecting power and dish diameter:

collecting power $\propto D^2$?

TELESCOPES ACROSS THE SPECTRUM

CHECK YOURSELF

What diameter would a radio telescope observing at 0.21 m need to match the resolving power of a 10 cm optical telescope working at 5.0×10^{-7} m? Comment on the answer.

Hint: Find the optical telescope's θ first; then ask what D gives the radio dish the same θ.

TELESCOPES ACROSS THE SPECTRUM

SPOT THE ERROR

Say what is wrong with this claim:

Observatories sit on mountaintops to be closer to the stars.

TELESCOPES ACROSS THE SPECTRUM

DEFINITION

Define: Apparent magnitude.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

Define: Absolute magnitude.

STAR BRIGHTNESS AND MAGNITUDE

CHECK YOURSELF

$M = f_o/f_e = 900 / 15 = 60$: millimetres are fine as long as both lengths use them.

Through the eyepiece Jupiter subtends $60 \times 2.4 \times 10^{-4} = 1.4 \times 10^{-2}$ rad, half as big again as the Moon appears unaided.

Normal adjustment: the two focal planes coincide, so the final image sits at infinity and a relaxed eye views it.

TELESCOPES AND IMAGE FORMATION

DEFINITION

The angle subtended by the final image at the eye divided by the angle subtended by the object at the unaided eye.

TELESCOPES AND IMAGE FORMATION

EQUATION — NOT ON THE DATA SHEET

collecting power $\propto D^2$

TELESCOPES ACROSS THE SPECTRUM

SPOT THE ERROR

Magnification is cheap — swap the eyepiece. What separates telescopes is the objective's diameter, which fixes how much light is gathered and how fine a detail can be resolved. Magnifying a blurred image just gives you bigger blur.

TELESCOPES AND IMAGE FORMATION

SPOT THE ERROR

A few kilometres of altitude is nothing against light years — mountaintops are chosen to sit above as much of the turbulent, absorbing atmosphere as possible: thinner air, steadier images, and infrared windows that sea level never sees.

TELESCOPES ACROSS THE SPECTRUM

CHECK YOURSELF

Optical: $\theta \approx \lambda/D = 5.0 \times 10^{-7} / 0.10 = 5.0 \times 10^{-6}$ rad.

Radio: $D = \lambda/\theta = 0.21 / 5.0 \times 10^{-6} = 4.2 \times 10^{4}$ m.

A single dish 42 km across is not buildable, which is the point of the comment: matching a small optical telescope at radio wavelengths takes networks of dishes spread across the countryside, acting together as one giant aperture.

TELESCOPES ACROSS THE SPECTRUM

DEFINITION

The apparent magnitude a star would have at a distance of 10 parsecs.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

A star's brightness as seen from Earth, on the backwards scale where each step of 1 is a factor of 2.51 and smaller numbers are brighter.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

Define: Parsec.

STAR BRIGHTNESS AND MAGNITUDE

CHECK YOURSELF

Vega has apparent magnitude 0.0 at a distance of 7.68 pc. Find its absolute magnitude. Then state which appears brighter from Earth, Sirius at $m = -1.5$ or Polaris at $m = +2.0$, and by what brightness factor.

Hint: Vega is nearer than the 10 pc shelf, so decide first whether M should be bigger or smaller than m.

STAR BRIGHTNESS AND MAGNITUDE

SPOT THE ERROR

Say what is wrong with this claim:

The bigger a star's magnitude number, the brighter it shines.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

Define: Black body.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

CHECK YOURSELF

A white dwarf has surface temperature 25 000 K and radiates 9.5×10^{24} W. Find its peak wavelength and its radius, and comment on the size.

Hint: Wien for the peak; rearrange Stefan for area, then radius from $A = 4\pi r^2$.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

SPOT THE ERROR

Say what is wrong with this claim:

A red-hot star is hotter than a white one.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

DEFINITION

Define: Hertzsprung–Russell diagram.

THE HR DIAGRAM AND STELLAR EVOLUTION

CHECK YOURSELF

Describe the future of the Sun as a track on the HR diagram, naming each stage, and explain in one sentence each why the Sun will not become a supernova and why type 1a supernovae can be used to measure distance.

Hint: Three stages on the diagram; then mass for the first sentence, fixed peak brightness for the second.

THE HR DIAGRAM AND STELLAR EVOLUTION

CHECK YOURSELF

$M = 0.0 - 5\log(0.768) = 0.0 + 0.57 = +0.6$: moved out to 10 pc, Vega would look slightly dimmer than it does now, as expected for a star nearer than 10 pc.

Sirius appears brighter: −1.5 is smaller than +2.0.

The gap is 3.5 magnitudes, so the ratio is $2.51^{3.5} \approx 25$ times.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

The distance at which one astronomical unit subtends an angle of one arcsecond: about 3.26 light years.

STAR BRIGHTNESS AND MAGNITUDE

DEFINITION

A body that absorbs all radiation falling on it and is therefore the best possible emitter, with a spectrum that depends only on its temperature.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

SPOT THE ERROR

The magnitude scale runs backwards, by ancient convention: first-magnitude stars are the brightest, sixth the faintest naked-eye ones. Each step of one magnitude is a factor of about 2.51 dimmer, and the very brightest objects go negative.

STAR BRIGHTNESS AND MAGNITUDE

SPOT THE ERROR

Colour reads temperature the opposite way round: red stars are the coolest, around 3000 K, and blue-white the hottest. Wien's law says hotter means a shorter peak wavelength — a poker heats from red towards white, never the reverse.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

CHECK YOURSELF

$\lambda_{max} = 2.9 \times 10^{-3} / 25\,000 = 1.2 \times 10^{-7}$ m, deep in the ultraviolet.

$A = P/\sigma T^4 = 9.5 \times 10^{24} / (5.67 \times 10^{-8} \times 25\,000^4) = 4.3 \times 10^{14}$ m^2, so $r = \sqrt{A/4\pi} = 5.8 \times 10^6$ m.

That is about the radius of the Earth: a star's worth of matter, hotter than the Sun's surface, packed into a planet's volume.

BLACK-BODY RADIATION AND SPECTRAL CLASSES

CHECK YOURSELF

The Sun sits on the main sequence now; when core hydrogen runs low it swells and cools, moving up and to the right as a red giant; after shedding its outer layers the remnant drops down-left as a white dwarf, then cools and fades.

No supernova: the Sun's mass is far below what core collapse requires, so its endpoint is the white dwarf.

Type Ia supernovae all detonate at the same trigger mass and so peak at the same absolute magnitude, about −19.3; comparing that with the measured apparent magnitude gives the distance through the distance modulus.

THE HR DIAGRAM AND STELLAR EVOLUTION

DEFINITION

A plot of stellar luminosity or absolute magnitude against temperature or spectral class, with temperature decreasing to the right.

THE HR DIAGRAM AND STELLAR EVOLUTION

SPOT THE ERROR

Say what is wrong with this claim:

The Sun will end its life in a supernova.

THE HR DIAGRAM AND STELLAR EVOLUTION

DEFINITION

Define: Red shift.

THE DOPPLER EFFECT AND HUBBLE'S LAW

DEFINITION

Define: Cosmic microwave background.

THE DOPPLER EFFECT AND HUBBLE'S LAW

CHECK YOURSELF

A quasar shows $z = 0.15$. Estimate its recession speed and its distance for $H = 65$ km s^{-1} Mpc^{-1}, and explain one reason the answer is only an estimate.

Hint: $v = zc$ first; then keep v in km per second so H's units do the conversion.

THE DOPPLER EFFECT AND HUBBLE'S LAW

SPOT THE ERROR

Say what is wrong with this claim:

The Big Bang was an explosion at a point in space, and the galaxies are its shrapnel.

THE DOPPLER EFFECT AND HUBBLE'S LAW

DEFINITION

Define: Quasar.

QUASARS AND EXOPLANETS

DEFINITION

Define: Radial velocity method.

QUASARS AND EXOPLANETS

DEFINITION

Define: Transit method.

QUASARS AND EXOPLANETS

DEFINITION

The fractional increase in the wavelength of light from a receding source: $z = \Delta\lambda/\lambda$.

THE DOPPLER EFFECT AND HUBBLE'S LAW

SPOT THE ERROR

A supernova needs a giant star's mass. The Sun is far too light: it will swell to a red giant, shed its envelope, and settle as a white dwarf cooling for eternity — no explosion, no neutron star.

THE HR DIAGRAM AND STELLAR EVOLUTION

CHECK YOURSELF

$v = zc = 0.15 \times 3.0 \times 10^8 = 4.5 \times 10^7$ m s^{-1}, or 45 000 km s^{-1}.

$d = v/H = 45\,000 / 65 = 690$ Mpc.

At fifteen per cent of light speed the small-shift approximation $z = v/c$ is beginning to strain, and H itself is only known roughly; both make the distance an estimate rather than a measurement.

THE DOPPLER EFFECT AND HUBBLE'S LAW

DEFINITION

Black-body radiation at 2.7 K arriving uniformly from every direction: the cooled, red-shifted afterglow of the hot early universe.

THE DOPPLER EFFECT AND HUBBLE'S LAW

DEFINITION

The active nucleus of a distant galaxy, powered by a supermassive black hole: galaxy-scale power from a volume the size of the solar system.

QUASARS AND EXOPLANETS

SPOT THE ERROR

The Big Bang happened everywhere at once: it is space itself that expands, carrying every galaxy away from every other. There is no centre to point at — observers in any galaxy see the same recession, $v = Hd$.

THE DOPPLER EFFECT AND HUBBLE'S LAW

DEFINITION

Detecting an exoplanet from the periodic dip in a star's brightness as the planet crosses its face.

QUASARS AND EXOPLANETS

DEFINITION

Detecting an exoplanet from the periodic Doppler shift of its star's spectral lines as star and planet orbit their common centre of mass.

QUASARS AND EXOPLANETS

CHECK YOURSELF

A quasar's brightness varies noticeably over about two days. Explain what this says about its size, and why that observation, combined with its red shift, forces an extraordinary power source.

Hint: Nothing can synchronise a change faster than light can cross the object.

QUASARS AND EXOPLANETS

SPOT THE ERROR

Say what is wrong with this claim:

We find planets around other stars by photographing them beside their suns.

QUASARS AND EXOPLANETS

SPOT THE ERROR

Beside its star, a planet is a firefly next to a lighthouse — direct photographs are rare exceptions. Exoplanets are found indirectly: the star's tell-tale Doppler wobble, or the tiny periodic dimming as the planet transits.

CHECK YOURSELF

A source cannot brighten as a whole faster than light can cross it, so its diameter is at most about two light-days, roughly 5×10^{13} m: solar-system sized, not galaxy sized.

The large red shift places the quasar billions of parsecs away by Hubble's law, and to be visible at all from there it must radiate more power than a whole galaxy.

Galaxy-scale power from a solar-system-scale volume rules out ordinary starlight; only matter heating violently as it falls towards a supermassive black hole fits both facts at once.