Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics
Advanced
Unit 5: Physics from Creation to Collapse

Wednesday 2 February 2011 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL questions

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following statements about nuclear fission is correct?

☒ **A** A uranium-235 nucleus can only undergo fission after absorbing a proton.

☒ **B** Kinetic energy is conserved during fission.

☒ **C** Linear momentum is not conserved during fission.

☒ **D** The fission fragments have a total mass less than that of the nucleus just before fission.

(Total for Question 1 = 1 mark)

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2 Which of the following statements is correct?

☒ **A** Electrostatic forces have a much longer range than gravitational forces.

☒ **B** Gravitational forces have a much longer range than electrostatic forces.

☒ **C** Gravitational and electrostatic forces both obey an inverse square law.

☒ **D** Gravitational and electrostatic field strength are both scalar quantities.

(Total for Question 2 = 1 mark)

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3 Two different sized boxes, P and Q, both contain the same number of nitrogen molecules. The molecules in box P have twice the root mean square speed of those in box Q. Which of the following must be correct?

☒ **A** The density of the gas in box P is greater than that in box Q.

☒ **B** The mean momentum of the molecules in box P is greater than those in box Q.

☒ **C** The pressure exerted by the gas in box P is greater than that in box Q.

☒ **D** The temperature of the gas in box P is greater than that in box Q.

(Total for Question 3 = 1 mark)

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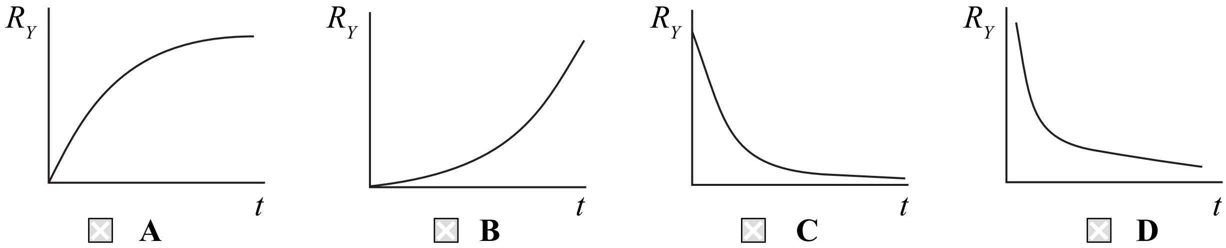
4 A sample of radioactive element X decays into a stable element Y. Which graph shows the rate of formation of element Y, R_Y with time, t?



(Total for Question 4 = 1 mark)

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5 Two stars with the same luminosity might produce different radiation fluxes at Earth. This is primarily due to the stars having different

- ☒ **A** diameters
- ☒ **B** distances from the Earth
- ☒ **C** motions through the Universe
- ☒ **D** surface temperatures

(Total for Question 5 = 1 mark)

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6 The gravitational field strength at the surface of Mars is one third that at the surface of the Earth. A mass-spring system with a frequency of 3.0 Hz at the surface of the Earth would have a frequency at the surface of Mars of

- ☒ **A** 5.2 Hz
- ☒ **B** 3.0 Hz
- ☒ **C** 1.7 Hz
- ☒ **D** 1.0 Hz

(Total for Question 6 = 1 mark)

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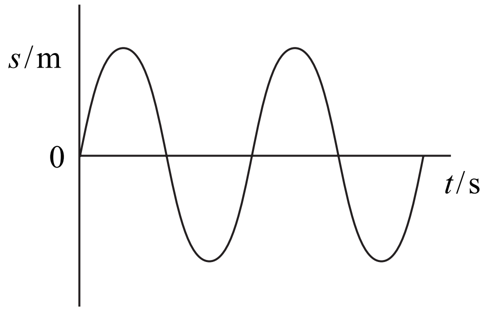
7 Which of the following statements about the possible fate of the Universe is **not** correct?

- ☒ **A** If the Universe is open then it will continue to expand forever.
- ☒ **B** If the Universe is open then it will eventually reach a maximum size.
- ☒ **C** If the Universe is closed then it will eventually reach a maximum size.
- ☒ **D** If the Universe is closed then it will reach a maximum size and then contract.

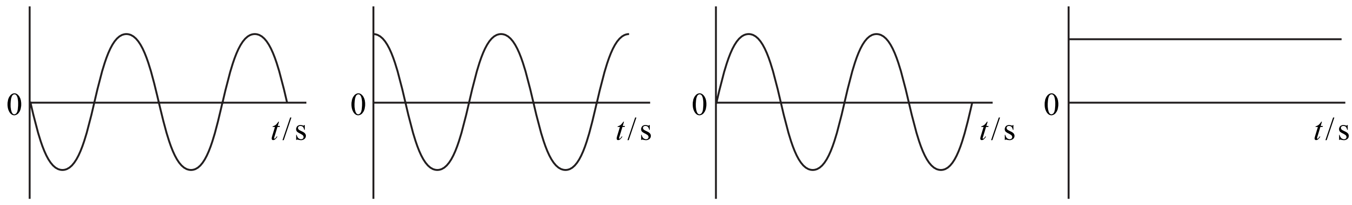
(Total for Question 7 = 1 mark)

Use the graphs below for questions 8, 9 and 10.

The graph below shows how displacement varies with time for a particle moving with undamped simple harmonic motion during a particular time interval.



For each of the questions 8 to 10, which of the following graphs best represents the quantities described during the corresponding time interval? Each graph may be used once, more than once or not at all.



A **B** **C** **D**

8 The velocity of the particle.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 1 mark)

9 The acceleration of the particle.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 The total energy of the particle.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) A typical aerosol can is able to withstand pressures up to 12 atmospheres before exploding. A 3.0×10^{-4} m^3 aerosol contains 3.0×10^{22} molecules of gas as a propellant. Show that the pressure would reach 12 atmospheres at a temperature of about 900 K.

1 atmosphere = 1.0×10^5 Pa

(2)

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*(b) Some such aerosol cans contain a liquid propellant. The propellant exists inside the can as a liquid and a vapour. Explain what happens when such an aerosol can is heated to about 900 K.

(3)

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(Total for Question 11 = 5 marks)

12 The planet Mars has a mean distance from the Sun of 2.3×10^{11} m compared with the Earth's mean distance from the Sun of 1.5×10^{11} m.

(a) Calculate the ratio $\dfrac{\text{Sun's radiation flux at distance of Mars}}{\text{Sun's radiation flux at distance of Earth}}$.

(2)

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Ratio = ...

(b) With reference to your answer in (a), comment on the suggestion that Mars could be capable of supporting life.

(2)

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(Total for Question 12 = 4 marks)

13 A Cepheid variable star contracts and expands repeatedly and as it does, so its luminosity varies. By measuring the period of this variation, astronomers can determine the star's average luminosity.

(a) A Cepheid variable star is a type of standard candle. Discuss the use of standard candles in astronomy.

(4)

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(b) As well as the variation in luminosity of the Cepheid, changes in the frequency of the detected radiation are also observed.

Suggest how the Doppler effect may account for these changes.

(2)

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(Total for Question 13 = 6 marks)

14 A copper wire, diameter 1.63 mm and length 105 km, is to be melted down to sell for scrap.

(a) (i) Show that the mass of the wire is about 2000 kg.

density of copper = 8960 kg m^{-3}

(3)

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(ii) The wire is initially at a temperature of 25 °C and its melting point is 1085 °C. Calculate the energy required to raise the temperature of the wire to its melting point.

specific heat capacity of copper = 385 J kg^{-1} K^{-1}

(2)

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Energy = ...

(b) Once the melting point is reached, there is no further increase in temperature until all of the copper has melted. Discuss what happens to the energy of the copper atoms before and during the melting process.

(2)

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(Total for Question 14 = 7 marks)

15 The Moon takes 27.3 days to make one complete orbit of the Earth.

(a) (i) Show that the orbital angular velocity of the Moon is about 3×10^{-6} rad s^{-1}.

(2)

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(ii) Calculate the radius of the Moon's orbit.

mass of Earth = 6.4×10^{24} kg

(4)

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Radius = ...

(b) The Moon is gradually moving further away from the Earth because of the action of tides.

(i) State and explain how this increasing distance affects the moon's orbital period.

(2)

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(ii) In 200 years the radius of the Moon's orbit is predicted to increase by 8 m.

Calculate the rate of increase of the radius of the orbit in cm per year.

(1)

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Rate of increase = ... cm per year

*(iii) In practice, the rate of increase of the orbital radius due to tidal action will not have been constant. Suggest why this rate of change might have been different in the very distant past.

(3)

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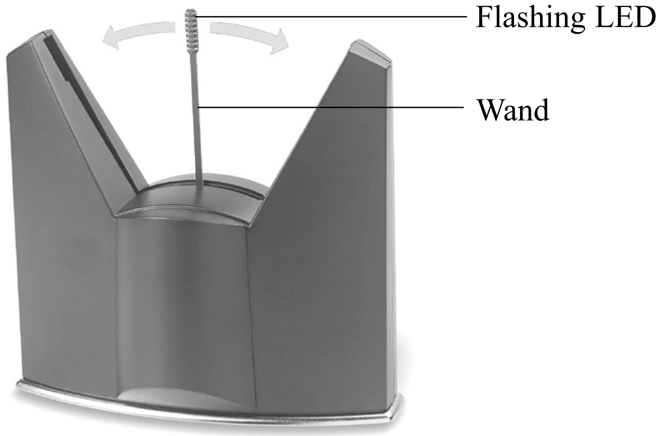
(Total for Question 15 = 12 marks)

16 Observing the display of a 'floating image' clock relies on the phenomenon of 'persistence of vision'. The clock has a wand with a set of flashing light-emitting diodes (LEDs) at its end. The wand oscillates rapidly back and forth and takes only 0.0625 s to sweep from one end to the other. The wand becomes almost invisible to the eye, while the flashing LEDs create a floating image effect.



(a) The tip of the wand moves with simple harmonic motion as it sweeps through a distance of 10.0 cm from one end to the other.

(i) Calculate the frequency of the wand's oscillation.

(2)

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Frequency = ...

(ii) The speed of the wand varies as it sweeps back and forth. At what point will the speed of the wand be a maximum?

(1)

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(iii) Calculate the maximum speed of the tip of the wand.

(2)

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Maximum speed = ...

(b) In normal operation the clock may make a faint ticking or humming sound. An unstable surface supporting the clock can result in noisy operation due to resonance.

(i) Explain what is meant by resonance.

(2)

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(ii) The clock is mounted on rubber feet so that it does not make direct contact with surfaces. Explain how this helps to reduce the effects of resonance.

(2)

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(Total for Question 16 = 9 marks)

17 In September 1987, two youngsters in Brazil removed a stainless steel cylinder from a machine in an abandoned clinic. Five days later they sold the cylinder to a scrap dealer who prised open a platinum capsule inside to reveal a glowing blue powder. The powder was found to contain caesium-137 and had an activity of 5.2×10^{13} Bq.

Caesium-137 is a β^--emitter with a half-life of 30 years.

*(a) Discuss the dangers to the youngsters of possessing this cylinder for 5 days.

(3)

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(b) Complete the equation to represent the decay of caesium-137 into barium.

(2)

$$^{137}_{55}\text{Cs} \rightarrow \,^{\cdots}_{\cdots}\text{Ba} + \,^{\cdots}_{\cdots}\beta^-$$

(c) (i) The decay of caesium into barium is a random process. Why is the decay process described as random?

(1)

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(ii) Show that the decay constant for the caesium-137 is about 7×10^{-10} s^{-1}.

(2)

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(d) In September 2007, 20 years after the cylinder was removed from the machine, the substance was still highly radioactive. Calculate the number of caesium-137 atoms remaining in the powder.

(4)

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Number = ...

(e) Caesium-137 is one of the products from the nuclear fission of uranium-235 in a nuclear reactor.

(i) Complete the equation for this reaction and show the number of neutrons released.

(1)

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{137}_{55}Cs + ^{95}_{\dots}Rb + \dots ^{1}_{0}n$$

(ii) Explain the significance to the operation of the reactor of the number of neutrons emitted in each fission.

(2)

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(Total for Question 17 = 15 marks)

18 Records of people walking on fire have existed for thousands of years. Walking across hot coals without getting burned does seem impossible, especially when the coals are at a temperature of 1500 K. However, as long as they do not take too long to walk across the coals, firewalkers won't get burned.

The explanation may have something to do with the relatively small amount of thermal energy involved. Although the coals are hot, the total amount of thermal energy transferred to the soles of the walker's feet is small. This is a little like quenching a red hot metal bar in a trough of cold water. The metal bar cools rapidly, transferring thermal energy to the water, but the rise in temperature of the water is quite small because of the relatively large value for the specific heat capacity of the water.

(a) Describe an experiment you could carry out to measure the specific heat capacity of a metal, assuming that you have a number of metal washers which can be heated to a known temperature in a Bunsen flame and plunged into a container of water. State the measurements that you would need to make and give the theoretical basis of the calculation that you would carry out.

What assumption would you make in calculating the specific heat capacity of the metal?

(4)

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(b) Coals used for firewalking typically glow a dull red, with the peak energy emission taking place at a wavelength of about 2 μm.

(i) To which region of the electromagnetic spectrum does this wavelength belong?

(1)

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(ii) Show that a peak wavelength of 2.00 μm corresponds to a black-body temperature of about 1500 K.

(2)

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(iii) The coals have an average radius of 2.5 cm. Assuming that each coal behaves as a black-body radiator, calculate the rate at which energy is radiated from each coal at a temperature of 1500 K.

(3)

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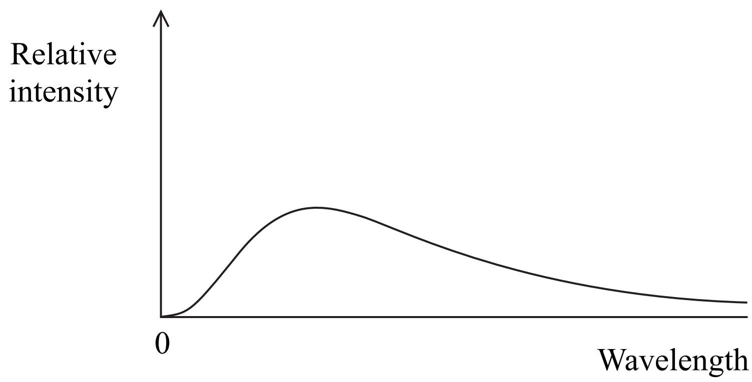
(iv) The graph shows the shape of the spectrum for radiation emitted from a black-body radiator at 1500 K. Add a second curve to show the shape of the spectrum for a temperature of 2000 K.

(2)



(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19} \text{ C}$	
Electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8} \text{ m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young's modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\%\ \text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

$$\%\ \text{efficiency} = \frac{\text{useful power output}}{\text{power input}} \times 100$$

Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{½}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's Law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$

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