Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Physics

Advanced
Unit 5: Physics from Creation to Collapse

Friday 24 January 2014 – Morning
Time: 1 hour 35 minutes

Paper Reference
WPH05/01

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 ▶

PEARSON

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 A physics student reads in a textbook that radioactive decay is a random process. This means that, for a sample of a given radioactive isotope, we cannot tell

☒ **A** what the radioactive isotope will decay into.

☒ **B** when the sample will start to decay.

☒ **C** which radioactive nucleus will decay next.

☒ **D** which type of radiation will be emitted.

(Total for Question 1 = 1 mark)

2 A mass is hung from a vertical spring and set into vertical oscillation.

The time period will

☒ **A** decrease as energy is lost from the system.

☒ **B** decrease as the amplitude decreases.

☒ **C** increase as the amplitude decreases.

☒ **D** stay constant provided the spring obeys Hooke's law.

(Total for Question 2 = 1 mark)

3 Protons experience both electric and gravitational forces.

Comparing the forces between two protons in a nucleus, it is correct to say that the

☒ **A** electric force is much stronger than the gravitational force.

☒ **B** gravitational force is much stronger than the electric force.

☒ **C** electric force is shorter range than the gravitational force.

☒ **D** gravitational force is shorter range than the electric force.

(Total for Question 3 = 1 mark)

4 There is uncertainty in the value of the Hubble constant determined by astronomers because

☒ **A** detailed observations have only been possible recently.

☒ **B** distances to distant galaxies are uncertain.

☒ **C** the age of the universe is uncertain.

☒ **D** the Big Bang is only a theory.

(Total for Question 4 = 1 mark)

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5 Recent observations have led scientists to propose the existence of dark matter.

Dark matter

☒ **A** is a perfect black body radiator.

☒ **B** is at a temperature very close to absolute zero.

☒ **C** may account for most of the matter in the universe.

☒ **D** will be discovered in high energy particle accelerators.

(Total for Question 5 = 1 mark)

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6 Absolute zero is the temperature reached when

☒ **A** an ideal gas liquefies.

☒ **B** an object is in deep space.

☒ **C** atoms have no kinetic energy.

☒ **D** a white dwarf ends its life.

(Total for Question 6 = 1 mark)

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7 Which of the following is **not** a source of background radiation?

☒ **A** coffee beans

☒ **B** granite rock

☒ **C** microwave ovens

☒ **D** people

(Total for Question 7 = 1 mark)

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8 A mixture of helium He and hydrogen H_2 gases is maintained at a temperature of 300 K.

Which of the following is correct?

☒ **A** The average kinetic energy of the He molecules is greater than the average kinetic energy of the H_2 molecules.

☒ **B** The average kinetic energy of the He molecules is the same as the average kinetic energy of the H_2 molecules.

☒ **C** The average speed of the He molecules is greater than the average speed of the H_2 molecules.

☒ **D** The average speed of the He molecules is the same as the average speed of the H_2 molecules.

(Total for Question 8 = 1 mark)

9 When a large number of people walk across a suspension bridge simultaneously the bridge may be set into oscillation.

This is an example of

☒ **A** forced oscillation.

☒ **B** free oscillation.

☒ **C** natural oscillation.

☒ **D** normal oscillation.

(Total for Question 9 = 1 mark)

10 When viewed from the Earth, light from a distant galaxy is observed to be red-shifted.

This is evidence that

☒ **A** the distant galaxy is moving away from the Earth.

☒ **B** the Earth is rotating about the Sun.

☒ **C** the Earth is rotating on its axis.

☒ **D** the universe is expanding uniformly.

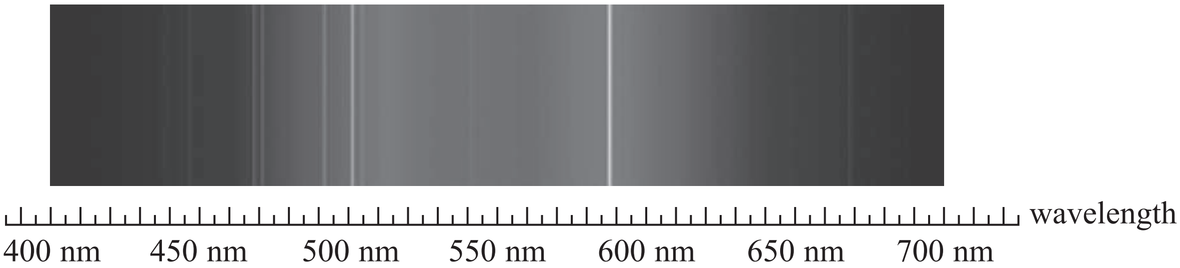
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The yellow line emitted by a helium discharge tube in the laboratory has a wavelength of 587.5 nm.



The same line in the helium spectrum of a star has a measured wavelength of 595.6 nm.

Calculate the speed of the star relative to the Earth.

(2)

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Speed = ...

(Total for Question 11 = 2 marks)

12 A typical car has an internal volume of 2.5 m^3. On a fine day the Sun heats the interior of the car from a temperature of 20 °C to a temperature of 55 °C.

(a) Calculate the number of molecules of air that must escape from the car if the pressure is to remain constant.

atmospheric pressure = 101 kPa

(4)

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Number of molecules = ...

(b) State an assumption that you made.

(1)

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(Total for Question 12 = 5 marks)

13 (a) Explain how the light emitted from a star enables us to determine the temperature of the star and hence its luminosity.

(3)

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*(b) An object whose luminosity is known may be referred to as a standard candle.

Explain why standard candles are important to astronomers and outline how standard candles are used to find distances to stars.

(3)

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(Total for Question 13 = 6 marks)

14 The physicist James Joule married in 1847 and visited the Cascade de Sallanches whilst on his honeymoon. This is one of the tallest vertical waterfalls in France, with the largest drop falling for just over 270 m.

It is claimed that, whilst at the waterfall, Joule performed an experiment to measure the temperature of the water at the top and bottom.

(a) (i) Consider 1.0 kg of water falling through a distance of 270 m.

Show that the temperature rise due to the gravitational potential energy change is about 0.6 K.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

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(ii) State an assumption that you made.

(1)

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(b) A physics student plans to repeat Joule's experiment.

She intends to use a thermometer with a precision of 0.25 K.

Discuss the extent to which she will be able to draw a valid conclusion from her measurements with this thermometer.

(3)

(Total for Question 14 = 7 marks)

15 From the 1960s to the 1980s nuclear-powered electronic pacemakers were sometimes used to regulate the heartbeat. Such pacemakers were used inside the body and were powered by a small radioactive source.

One type of pacemaker used an isotope of plutonium, Pu-238, as its energy source.

Pu-238 decays by alpha emission with a half-life of 88 years.

(a) Explain why the alpha particles were not harmful to the person fitted with the pacemaker.

(2)

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(b) Complete the equation for plutonium decaying into thorium.

(2)

$$^{238}_{92}\text{Pu} \rightarrow {}^{\cdots}_{\cdots}\text{Th} + {}^{\cdots}_{\cdots}\alpha$$

P 4 3 1 1 5 A 0 1 0 2 4

(c) The activity of the source in one such pacemaker, when the pacemaker was fitted, was 9.3×10^{10} Bq. The energy released by each alpha decay is 5.5 MeV.

Calculate the power of the source 30 years after fitting.

(6)

Power of source = ... W

(d) Modern pacemakers use a lithium (chemical) battery with a lifetime of about 5 years.

Suggest **one** advantage and **one** disadvantage of using a lithium battery pacemaker compared with one powered by a plutonium source.

(2)

Advantage ....

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Disadvantage ....

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(Total for Question 15 = 12 marks)

16 Europa is a moon of Jupiter. Europa is thought to contain an abundant supply of water and is therefore seen as a possible place for primitive life.

(a) Calculate the value of g at the surface of Europa.

mass of Europa = 4.8×10^{22} kg
radius of Europa = 1600 km

(2)

g = ...

(b) Explain how Europa is maintained in a circular orbit about Jupiter.

(2)

(c) Calculate the time taken for Europa to make one orbit.

mass of Jupiter = 1.90×10^{27} kg
radius of Europa's orbit = 6.71×10^{5} km

(3)

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Time taken = ...

(d) The average distance of Jupiter from the Sun is 5.2 times the average distance of the Earth from the Sun.

Calculate the ratio of the brightness (flux) of the Sun as seen from the Earth to the brightness as seen from Jupiter.

(3)

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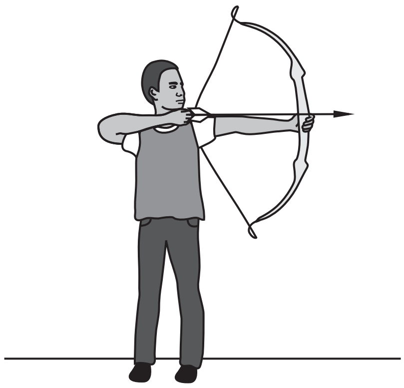
Ratio = ...

(Total for Question 16 = 10 marks)

17 An archer is carrying out some target practice with his bow and arrow.



He attaches an apple to a spring hung from a fixed support and sets the apple into vertical oscillation of amplitude 10 cm. The apple performs simple harmonic motion with a frequency of 0.625 Hz.

(a) Describe the conditions required for an oscillation to be simple harmonic.

(2)

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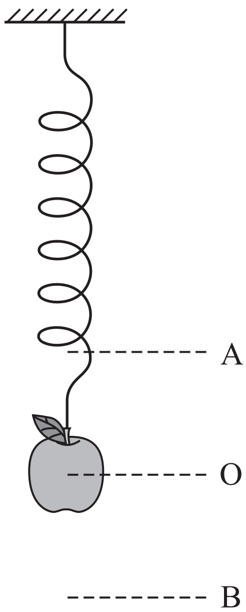
(b) The diagram shows the apple on the spring. A and B are the positions of maximum displacement and O is the equilibrium position of the apple.



Sketch a graph to show how the displacement of the apple varies with time.

(4)

(c) Calculate the maximum velocity of the apple as it oscillates.

(3)

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Maximum velocity = ...

(d) The archer fires an arrow towards the apple as it is oscillating.

Explain at which position of the apple the archer has the best chance of scoring a direct hit.

(2)

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*(e) Over time the amplitude of the apple's oscillation will decrease to zero.

Explain how the principle of conservation of energy applies to this situation.

(3)

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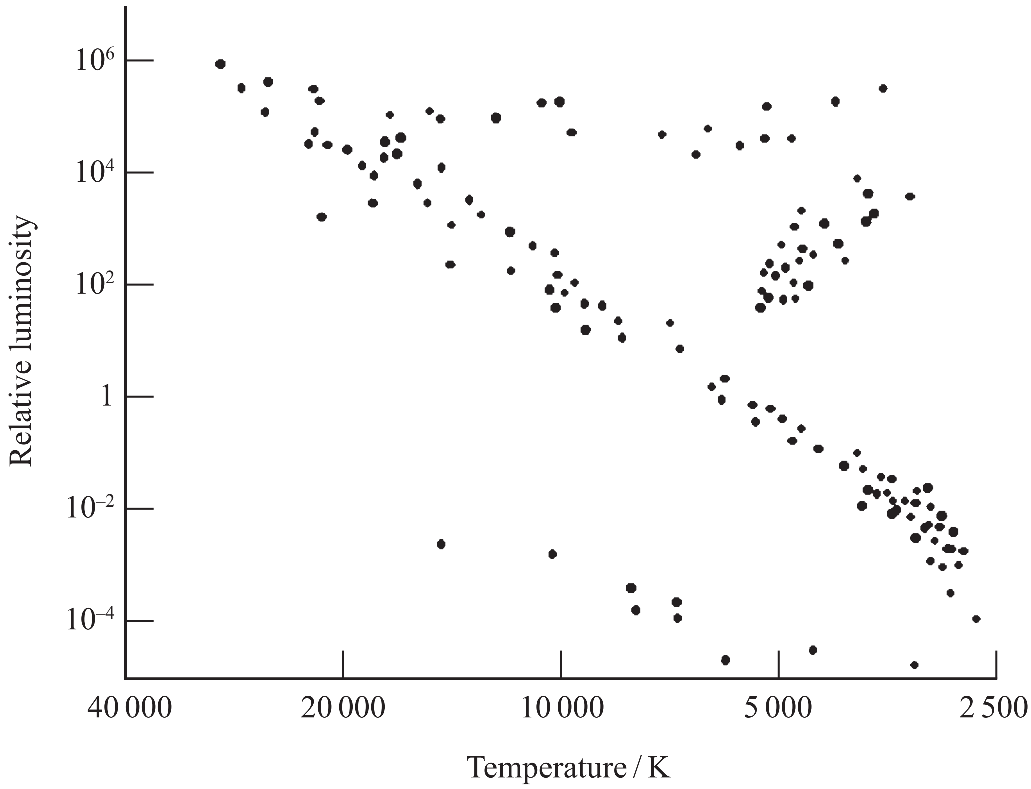
(Total for Question 17 = 14 marks)

18 Astronomers have been watching an old star suddenly stir back into new activity.

(a) They are studying a star known as "Sakurai's Object", an old white dwarf that has run out of hydrogen fuel for nuclear fusion reactions in its core. Astronomers now believe that some such stars can undergo a final burst of fusion.

Computer simulations indicate that convection would bring hydrogen in from the star's outer regions, causing a brief flash of new nuclear fusion. This produces a sudden increase in the size and brightness of the star.

The diagram below is a Hertzsprung-Russell diagram.



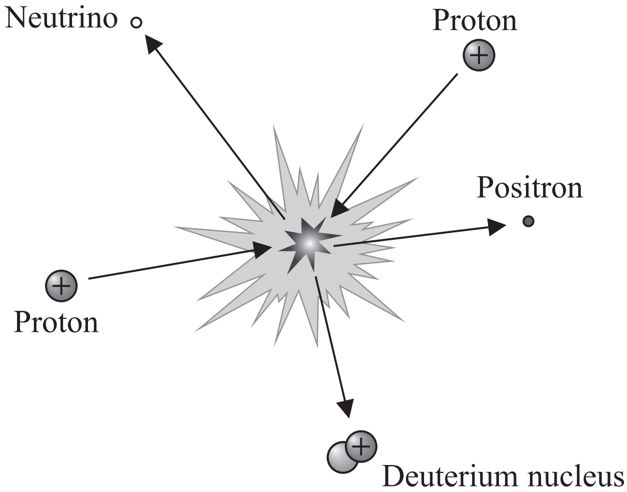
(i) On the diagram, mark a likely position for Sakurai's Object before the final burst of fusion took place. Label this X.

(1)

(ii) On the diagram, mark a likely position for Sakurai's Object during the final burst of fusion. Label this Y.

(1)

(b) During the hydrogen fusion process the first stage is the fusion of two protons to form a deuterium nucleus.



Particle	Mass / MeV/c^2
Deuterium nucleus	1875.62
Electron	0.51
Proton	938.27

(i) Complete the nuclear equation to represent the fusion of two protons to form a deuterium nucleus.

(1)

$$^{1}_{1}\mathrm{p} + {}^{1}_{1}\mathrm{p} \rightarrow$$

(ii) Calculate the energy, in joules, emitted in this first stage.

(3)

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Energy emitted = ... J

(c) For fusion to take place in the core of a star there must be a very high density of hydrogen at an extremely high temperature.

Explain why.

(3)

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Question 18 continues on the next page.

*(d) The quest for a practical nuclear fusion reactor to contribute to our electrical power demands is hindered by the extreme conditions necessary. Nuclear fission already supplies a large fraction of this demand.

Discuss the potential advantages of nuclear fusion, compared with nuclear fission, as a means of supplying our power demands.

(5)

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

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

Unit 1

Mechanics

Kinematic equations of motion
$$v = u + at$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Forces
$$\Sigma F = ma$$
$$g = F/m$$
$$W = mg$$

Work and energy
$$\Delta W = F\Delta s$$
$$E_k = \tfrac{1}{2}mv^2$$
$$\Delta E_{grav} = mg\Delta h$$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \tfrac{1}{2}F\Delta x$

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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

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

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

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	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

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	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 \mathrm{e}^{-\lambda t}$

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	$v = H_0 d$