NEWINGTON COLLEGE

Physics

2001
TRIAL HSC EXAMINATION
answers and marking guide

Section I Pages 2-28

Total marks **(75)**

This section has two parts, Part A and Part B

Part A

Total marks **(15)** Pages 3-10

- Attempt Questions 1-15
- Allow about 30 minutes for this part

Part B

Total marks **(60)** Pages 11-28

- Attempt Questions 16-38
- Allow about 1 hour and 45 minutes for this part

Section I is presented in THREE sections:

- ♦ **Part A and Part B, Questions 16-22**
- ♦ **Part B2, Questions 23-30**
- ♦ **Part B3, Questions 31-37**

Section II Pages 29-36

Total marks **(25)**

- Attempt ONE question from Questions 38-40
- Allow about 45 minutes for this section

Section I
Total marks (75)

Part A
Total marks (15)
Attempt Questions 1-15
Allow about 30 minutes for this part

Start Here ➔

	A	B	C	D
1.	○	○	○	●
2.	○	○	○	●
3.	○	○	●	○
4.	○	○	●	○
5.	○	●	○	○
6.	○	○	○	●
7.	●	○	○	○
8.	○	●	○	○
9.	○	○	●	○
10.	●	○	○	○
11.	○	○	●	○
12.	○	●	○	○
13.	○	○	○	●
14.	○	○	○	●
15.	○	○	●	○

Average = 10.4 / 15

Section I

Part B
Total marks (60)
Attempt Questions 16-38
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (3 marks)

Mark Level	Band	You answer:
3	5	♦ outlines the technology used and identifies the data that were measured using it ♦ outlines at least one source of error using the technology and explains how this could affect the value of *g* derived from the data
2	4	♦ outlines the type of data gathered in a experiment to measure *g* and identifies one or more sources of error
1	3	♦ outlines major details of a viable procedure used to estimate *g*

A very common method referred to was the pendulum and the use of a stopwatch to measure sets of 10 oscillations (this word was seldom used, unfortunately) to average the period (this word was seldom used).
Very few could quote the relationship: $T = 2p\sqrt{\frac{l}{g}}$

Another was to drop an object through a known distance and use a stopwatch to measure the fall time. ***Very few could quote that, because*** $s = ut + \frac{1}{2}at^2$***, then*** $g = 2s / t^2$ ***when*** $u = 0$.

Marks

Question 17 (2 marks)

(a)

Mark Level	Band	You answer:
1	4	♦ identifies and elucidates a problem such as the attenuation of signals due to the inverse square law OR the intervention of atmospheric effects, causing attenuation, reflection, etc.

(b)

Mark Level	Band	You answer:
1	4	♦ identifies and elucidates a problem such as the effects of charged particles in ionising satellites and hence interfering with the receipt and transmission of electromagnetic waves

The level of knowledge and understanding of the van Allen belts ranged from thorough to nil. There was some quite authoritative writing about the genesis of strong electrical fields and magnetic fields (due to moving/accelerating charged particles in the van Allen belts) but hardly anyone went (did anyone go?) on to explain why such strong and fluctuating fields would cause a problem with electromagnetic signals. This effect was merely asserted by most people who took this line.
Please note that the van Allen belts get THREE mentions in the Syllabus; pages 45, 52, 55!!!!!! This MAY tell us someone.

Question 18 (3 marks)

Mark Level	Band	You answer:
3	5	♦ explains that gravitational slingshots involve conversions between gravitational potential energy to kinetic energy ♦ explains that momentum and kinetic energy are transferred from a planet to a spacecraft during these slingshot "fly-bys" (through the gravitational field) ♦ outlines how Kepler's 3rd Law applies by discussing the link between radius, orbital speed and period of orbit
2	4	♦ explains that the slingshot effect involves both energy transformation/transfer and momentum transfer from planet to spacecraft
1	3	♦ links the gravitational effects of a planet to changes in the motion of a spacecraft

Note that Kepler's 3rd Law is not really needed to explain the slingshot effect. It is well-explained by applying conservation of momentum and KE in a perfectly elastic (no KE losses) collision to the trajectory of a probe approaching a planet. Nevertheless, note p. 52, column 2 of the Syllabus, which *links Kepler's 3rd Law to the slingshot effect. In answering this question, it would be best to consider KE / period of orbit changes caused by the changing distance from the planet but also to discuss how the planet's orbital KE is used and transferred so that the maximum final v of the probe is* $v_f = v_I + 2v_{planet}$.

Question 19 (4 marks)

(a) Calculate the orbital speed required to maintain a craft in a LMO at a distance of 300 km above the surface of Mars. **2**
($m_{Mars} = 6.6 ´ 10^{23}$ kg; $r_{Mars} = 3.4 ´ 10^{6}$ m)

$r_{orbital} = r_{Mars}$ + altitude above surface = 3.7×10^6 m ....

$a_{centripetal} = v^2/r_{orbital} = a_{gravitational}$ ....

$a_{gravitational} = G\, M_{Mars} / (r_{orbital})^2$ ....

$v^2 = G\, M_{Mars} / r_{orbital} = 6.67 \times 10^{-11} \times 6.6 \times 10^{23} / 3.7 \times 10^6$ ....

$v_{orbital} = 3.4 \times 10^3$ m s^{-1} ....
Other similar methods were used. The most common was to calculate the escape velocity, which uses the same sort of concept of the motion.

(b)

Mark Level	Band	You answer:
1	4	♦ explains the frictional effects of the atmosphere on the orbital speed/kinetic energy of satellites

The wording of this question caused some confusion and those who referred to the lower value of g for Mars (at h = 300 km, which was not often stated) also gained the mark.

(c)

Mark Level	Band	You answer:
1	4	♦ describes how the re-entry of the Space Shuttle is *controlled*, so that it is inserted into the atmosphere at a precise angle

The two major concepts here were:

- *the control of the insertion angle (about 6˚) – but very few of you stated that it was 6˚ below the horizontal to prevent excessive frictional force due to a too-steep angle and a redirection of the Shuttle back into space due to a too-shallow angle*
- *the use of ceramic tiles as insulators for the capsule and as radiators of heat energy*

Marks

Question 20 (4 marks)

(a)

Mark Level	**Band**	**You answer:**
2	5	♦ clearly describes the main details of a typical *gedanken* scenario, particularly how two frames of reference with relative motion exist
1	4	♦ outlines the main details of a typical *gedanken* scenario

There was an understandable tendency to mix together

A typical gedanken scenario involves a train carriage, tram or bus travelling at relativistic speed compared to an observer by the side of the road or track and stationary with respect to his surroundings. There is an observer at each end of the train carriage. A signaller at the midpoint of the train sends out a light pulse that will be seen by the observer at each end of the carriage and by the observer at trackside. ***(This is the scenario. Now see below for some consequences.)***

(b)

Mark Level	**Band**	**You answer:**
2	5	♦ explains how and why the experiences of time and/or length and/or mass will differ in the 2 frames of reference developed in the scenario
1	4	♦ describes how the experiences of time and/or length and/or mass will differ in the 2 frames of reference developed in the scenario

There was generally little link between the gedanken in part (a) and the characteristics of motion described in part (b).

Note that Einstein's thought experiments are clearly referred to in the Syllabus (p. 53)

The signal will reach both observers at the ends of the train at the same time: the readings on their clocks will be the same and the same as the signaller's. There will be no effects due to relativity. From the point of view of the observer by the track, the observers in the train have relative motion and so the apparent time taken for light to travel to them over a given distance is the different from the time taken for it to travel to this "stationary" observer. The observers in the train perceive the opposite situation and so each sees time dilation of the other's frame of reference. Mutual perceptions of length contraction and mass increase in the frame of the OTHER *observer are also implied.*

The key omissions here in answers are the failure to consider both points of view and to make it clear that the relativistic observations due to the $1 / \sqrt{1-\frac{v^2}{c^2}}$ *factor are by an observer of the other's reference frame NOT of his OWN.*

Marks

Question 21 (2 marks)

Mark Level	Band	You answer:
2	4	♦ describes the work in rocketry undertaken by the named scientist ♦ explains how this work contributed to the further development of rocketry in subsequent years
1	3	♦ describes the work in rocketry undertaken by the named scientist

In general, the second dot in Band 4 was implied rather than clearly stated. Note that the questions asks for a comment on DEVELOPMENT OF ROCKETRY. Note also that this question appears in the Specimen Paper.

Question 22 (2 marks)

Mark Level	Band	You answer:
2	4	♦ relates at least TWO factors, based on the difficulty of launching spacecraft and/or the physics and science of survival in space, that cause space travel to be costly, especially for manned travel *(the most common answers were the fuel costs involved in launches to overcome the Earth's gravitational force and the technology required to provide water and food for astronauts and protect them from the hostile radiations, temperatures and vacuum of space)*
1	3	♦ correctly describes the work in rocketry undertaken by the named scientist

Those who dealt only with the given data did not interpret the words "account for". The data provided stimulus material. The question becomes "why are these figures as they are in terms of Physics and the course you have studied?". Please also refer to Syllabus page 53, column 3 – the relative energy costs of space travel (RELATED TO A COURSE IN PHYSICS!!!)

PART B2

Please write your 4/5 digit STUDENT NUMBER neatly in the boxes.

Marks

Question 23 (2 marks)

Upon reflection this question was not good. It was assumed that back emf was responsible. In fact emf change is not the central concept.

Basically, the dimming of the lights results from a current drain to the starter motor. Approximately 400 amps of current required by the starter motor. This current is drawn from the battery. Once the alternator is running, the starter motor is disengaged and so current is no longer required.

To obtain the full 2 marks, students should clearly use their knowledge of circuits and refer to motors and/or generators. I did allow students to use emf as an answer in marking as long as they clearly describe how it is produced and why this affects the lights.

In general this was done poorly, mainly due to the poor question, however many people failed to show great understanding of motor/generator system and circuits.

This question was poorly answered by many simply because they failed to address the question of 'Social Impact'.

Many students highlighted the transformers function or that many appliances use transformers but failed to connect the two ideas in a meaningful way.

To gain the full 2 marks, students should clearly identify what the transformer does and how this has impacted on society in Australia.

Question 24 (2 marks)

This question was poorly answered by many simply because they failed to address the question of 'Social Impact'.

Many students highlighted the transformers function or that many appliances use transformers but failed to connect the two ideas in a meaningful way.

To gain the full 2 marks, students should clearly identify what the transformer does and how this has impacted on society in Australia.

Sample Ideas

Transformers are able to step up or step down voltage by varying the number of coils in the primary and secondary coils. In doing so the transformer enables voltages which are both safe and practical to be used. A step down transformer enables households to use, 240V rather than 240,000V which has been delivered by high voltage power lines.

Another answer may talk about the impact of stepping up voltage to reduce power loss in these high voltage power lines, hence reducing costs to the consumer.

Question 25 (2 marks)

This question was answered quite well. However some students used an advantage as a disadvantage simultaneously while this can be true, I felt it better to give separate issues so that there con not be any ambiguity.

Advantages included:

1. *High voltage reduced the current, thus reducing power loss.*
2. *Transmitting over large distances enables power stations to be set up in areas suitable to the production (i.e.: Snowy Mountains Hydroelectric Scheme), and this reduces impact in cities/suburban areas.*

Disadvantages included:

1. *High voltage results in the production of electromagnetic radiation which has been linked with the incidence of cancer in people near these high voltage power lines.*
2. *Over large distance, some power is lost in the wires due to ohmic heating (however, this should not be linked with the above)*
3. *Large pylons and structures required to be set in place, thus increasing costs.*

Question 26 (2 marks)

This question sought to test people's knowledge on the production of eddy currents and how they enable braking to occur.

Eddy current braking results due to the interaction of the opposing magnetic fields. The 1st magnetic field is changing relative to the plates. This causes eddy currents to form. These eddy currents have an associated magnetic field (the 2nd magnetic field). These two magnetic fields oppose each other and thus result in the slowing of the plate's motion.

Many people simply stated that the eddy currents caused the braking, not the magnetic field interaction.

To gain full marks students must then comment on/account for the difference between plate A and plate B. This was due to the slits in plate B, allowing smaller eddy currents and, therefore, smaller magnetic fields.

Question 27 (5 marks)

Most students went part way with this question but many failed to 'account for' conservation of energy or relate the formation of currents to the production of magnetic fields.

A good answer would read like this:

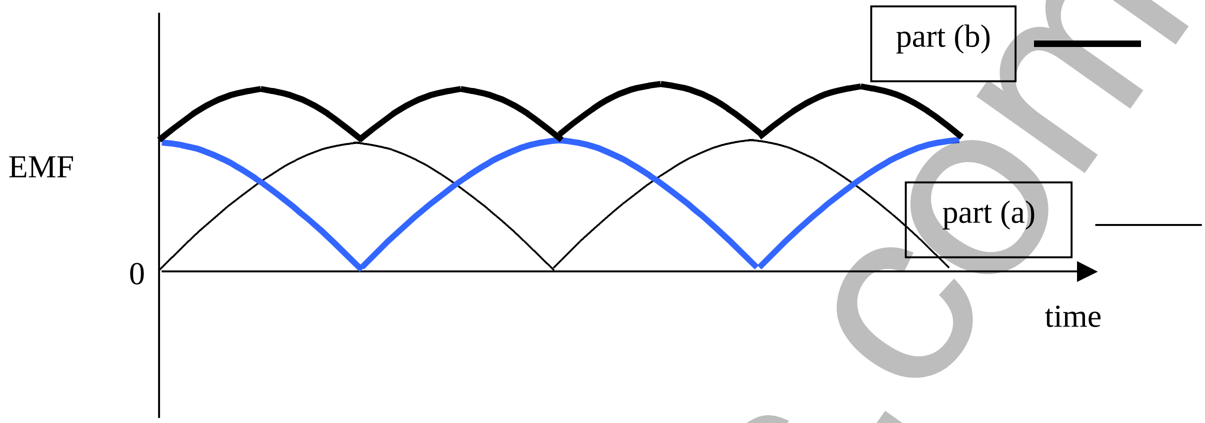
"As the magnet falls through the tube, a changing magnetic field, relative to the metal tube, creates a current in the tube. As Lenz's Law states, the magnetic field associated with this induced will be in opposition to the change in the magnetic field which caused it. The interaction of opposing magnetic fields causes the magnetic cylinder to fall more slowly than the non-magnetic piece of steel. Since energy must be conserved, the loss in gravitational potential energy (without a corresponding increase in kinetic energy) of the magnetic piece of steel must be transformed into other forms, such as electrical energy (induced current) and heat energy".

Some students responded poorly in the second part of the question.

Marks

Question 28 (2 marks)

Most students answered the first part well showing that the emf is reversed each half cycle by the commutators.



(b) However, part (b) was poorly done. Many students did not understand/show that the coil, at 90° was going to produce a similar emf but in a different time phase. The answer above shows how the 2 emfs are added.

Question 29 (2 marks)

This question was answered well. Most students recognised the difference between the terms slip-ring and split-ring. The concern is that some students were unable to distinguish between the 'function' and where they are used. Students must answer questions to gain full marks.

Question 30 (3 marks)

Many people failed to gain all 3 marks but most were awarded 2. The outline of the operation of an AC induction motor required a clear description of the changing magnetic field (produced by AC currents in coils around ferromagnetic material) and, hence, how the stator affects the rotor. The rotor is able to move and does so because it interacts with the stator's changing magnetic field. As the stator's magnetic field changes, the rotor experiences an induced current, which produces its own magnetic field to oppose the changing fields of the stator. This results in a dragging force which turns the rotor.

PART B3

Please write your 4/5 digit STUDENT NUMBER neatly in the boxes.

Question 31 (2 marks) **Marks**

(a) **1**

Light of high enough frequency will eject electrons from the surface of a material...........

(b) **1**

Your answer refers to the relationship between the intensity of light energy of a given wavelength reaching the photocell of the breathalyser and the photoelectric current produced in the photocell by this light energy.

Question 32 (5 marks)

Mark Level	Band	You answer:
5	6	♦ contains a clear, accurate description and comparison of the 2 bands, of a 'sea of electrons' model for conduction in metals, related to valence and conduction bands ♦ describes the nature of doping in semiconductors, explains the electron-hole theory of conduction and refers to electron bands and their separations as a model for semiconductivity ♦ compares and contrasts these 2 models
4	5	♦ contains a clear, accurate description and comparison of the 2 bands, of a 'sea of electrons' model for conduction in metals, related to valence and conduction bands ♦ describes the nature of doping in semiconductors and conductivity ♦ compares and contrasts these 2 models
3	4	♦ compares conductivity in metals and semiconductors, with reference to conduction and valence bands ♦ compares the energies involved in conductivity in each of the two types of materials
2	3	♦ contains a basic outline of conduction in metals and makes some comparison / contrast with conductivity in semiconductors
1	2	♦ describes the concept of conductivity, involving electron or charge flow

Marks

Question 33 (3 marks)

(a)

Mark Level	Band	You answer:
2	5	♦ relates wavelength inversely to photon / quantum energy ♦ makes a connection between the energy of photoelectrons ejected and their potential hazard to humans.
1	4	♦ makes one of the links above

(b) *Calculate* the photon energy of yellow light of wavelength 506 nm. **1**

$E = hc / \lambda = (6.63 \times 10^{-34}$ J s $\times$ 3.00×10^{8} m s^{-1}) / 5.06×10^{-9} m $= 3.93 \times 10^{-19}$ J ......

Question 34 (3 marks)

(a) **2**

They passed X-rays through various types of crystals and produced a diffraction pattern on the other side from the X-ray source. ....

(b) **1**

The symmetrical arrangement of atoms, ions or molecules in crystals. ....

The packing arrangement of atoms, ions or molecules in crystals. ....

The separation between the layers of particles in the crystal. ....

Question 35 (2 marks)

Mark Level	Band	You answer:
2	5	♦ discusses the interaction between particles (positive ions) in the crystal lattice and the flowing electrons of the electric current ♦ links the vibration of particles in the crystal to the emission of infra-red radiation
1	4	♦ makes one of the links above

Marks

Question 36 (2 marks)

Mark Level	Band	You answer:
2	4	♦ identifies that the circumference of the orbit of an electron has to correspond to a whole number of wavelengths of the electron's matter wave ♦ describes that energy levels are defined by the number of wavelengths of an electron at each level
1	3	♦ identifies that the circumference of the orbit of an electron has to correspond to a whole number of wavelengths of the electron's matter wave

Question 37 (3 marks)

Mark Level	Band	You answer:
3	5	♦ relates several potential advantages (e.g. in Maglev trains, in scanning applications such as medical MRI machines, in power transmission lines, in computer circuits as low energy, fast switches) and potential limitations of superconductors (e.g. the need to be maintained, presently, at low temperatures, their usually ceramic nature, leading to non-metallic properties, the tendency for high currents to produces vortices that can destroy the material) to their key properties (e.g. brittleness, lack of ductility, high conductivity / high current capacity, relatively low ohmic energy losses, need for them to be kept cooled to very low temperatures)
2	4	♦ is as above, except that the advantages and limitations are not clearly tied to a discussion of general principles and properties
1	3	♦ shows only limited knowledge and understanding of the properties and uses of superconductors

Section II

Total marks (25)
Attempt ONE question from Questions 38-40
Allow about 45 minutes for this section

Marks

Question 38 — Medical Physics (25 marks)

No answers given for Medical Physics

Marks

Question 39 — Astrophysics (25 marks)

No answers included for Astrophysics

Marks

Question 40 — From Quanta to Quarks (25 marks)

(a) (i)

Mark Level	Band	You answer:
1	4	♦ explains that nearly all α particles were undeflected by the gold foil OR explains that, remarkably, a very few α particles were reflected

(ii)

Mark Level	Band	You answer:
1	5	♦ mentions the concept that electrons orbitting the nucleus in Rutherford's model would lose energy by radiating photons

(b) (i)

Mark Level	Band	You answer:
2	5	♦ explains that, in atoms, electrons are confined to certain *fixed* energy levels or angular momentum values ♦ identifies and clearly states an appropriate postulate of Bohr *(in this case, either the quantisation of angular momentum postulate OR the stable electron orbit/energy postulate OR the emission of a photon during energy level changes postulate could be listed)*
1	4	♦ includes one or other of the points above

(ii)

Mark Level	Band	You answer:
2	5	♦ explains that, when electrons move between fixed energy states/angular momentum states, photons of predetermined wavelengths are emitted (energy level decrease) or absorbed (energy level increase) ♦ identifies and clearly states an appropriate postulate of Bohr *(in this case, the emission of a photon during energy level changes postulate would be the best one to choose)*
1	4	♦ includes one or other of the points above

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(c) (i)

Mark Level	Band	You answer:
1	4	♦ indicates that ΔE is equivalent to the energy of an absorbed photon and that $\Delta E = hf$ or hc/λ ΔE = photon energy = $hc / \lambda = 6.626 \times 10^{-34} \times 3.8 \times 10^{8} / 4.9 \times 10^{-7} = 5.1 \times 10^{-19}$ J (= 3.2 eV)

(ii)

Mark Level	Band	You answer:
1	4	♦ indicates that $\Delta E = \Delta V \times q_e$ $\Delta V = 5.1 \times 10^{-19}$ J / 1.6×10^{-19} C = 3.2 J C^{-1} = 3.2 V

(ii)

Mark Level	Band	You answer:
2	5	♦ identifies the link between $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ and $(\lambda \times R_H)$ in Rydberg's equation ♦ identifies n = 3 and n = 6 as the relevant quantum levels
1	4	♦ identifies the link between $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ and $(\lambda \times R_H)$ in Rydberg's equation

(d)

Mark Level	Band	You answer:
2	5	♦ identifies either the complex spectra or larger atom OR hyperfine spectral lines OR the Zeeman effect OR the varying relative intensity of spectral lines as an unpredictable effect ♦ refers to the existence of quantum states/quantum numbers other than the principal quantum number of Bohr *(for example, the Zeeman effect is a result of the existence of magnetic spin quantum states which become apparent as separate energy levels when an element's spectrum is recorded while it is immersed in an external magnetic field)*
1	4	♦ includes one or other of the points above

PAGE TOTAL

(e)

Mark Level	Band	You answer:
3	6	♦ describes de Broglie's postulate of electrons as matter waves, explains how it was applied to the description of electrons standing waves and explains the consequence of this description for fixing allowed electron energy levels/angular momentum states
2	5	♦ describes electrons as matter waves and examines how de Broglie used this concept to quantise the allowable energy / angular momentum levels of electrons
1	4	♦ describes the matter wave / standing wave view of electron orbits

(f)

Mark Level	Band	You answer:
3	6	♦ explains the essence of the Uncertainty Principle, examines its implications for atomic structure, especially for the nature of electrons and orbitals, and identifies ideas that grew from it (e.g. the Schrödinger probability wave function)
2	5	♦ describes aspects of the Uncertainty Principle and relates these to implications about the nature of atomic structure
1	4	♦ identifies implications of the Uncertainty Principle for atomic (especially electron) models

(g) (i)

Mark Level	Band	You answer:
2	5	♦ links loss of electrical PE to gain of KE ♦ applies the relationship $\frac{1}{2}m_e v^2 = \Delta V.q_e$ $\frac{1}{2} \times 9.109 \times 10^{-31} \times v^2 = 5.00 \times 10^3 \times 1.602 \times 10^{-19}$ $v = 4.2 \times 10^7$ m s^{-1}
1	4	♦ links loss of electrical PE to gain of KE

(ii)

Mark Level	Band	You answer:
2	5	♦ indicates that λ can be calculated from matter wave concept that $\lambda = p/mv$ or from Elect PE = KE = hc/λ ♦ indicates that maximum theoretical resolution is of the order of the wavelength of the electrons used
1	4	♦ includes one or other of the points above

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(iii)

Mark Level	Band	You answer:
1	5	♦ outlines a relevant factor affecting resolution (e.g. electrons have a spectrum of energies when they leave the cathode/electron gun; magnetic lenses are never geometrically perfect and lead to aberration / dispersion of electron energies)

(iv)

Mark Level	Band	You answer:
2	5	♦ explains how electron microscopic technology has been applied in cell biology, the information it has supplied and the research it has stimulated (e.g. electron microscopy allowed biologists to visualise structures / organelles within cells, to identify their forms and to suggest and investigate functions that reflect structure)
1	4	♦ describes the additional information that electron microscopes supplied about cell substructure compared with even the best light microscopes

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