CLOSED DOMAIN QUESTION ANSWERING

NLP COURSE PROJECT

Mathew George
B160008CS

Aim

To create a Closed Domain Question Answering System for 12th grade NCERT physics.

Motivation

- There is a gap in technology that aids students to obtain answers to questions directly from a textbook.
- Currently done by scouring online resources and regex search, which is cumbersome.
- To fill this gap, we propose a CDQA system.

Introduction

- Two types of Question Answering Systems:
  - Closed Domain Question Answering System: Questions restricted to a particular domain.
  - Open Domain Question Answering System: No restrictions on the domain for questions.
- We aimed to build a CDQA system through this project.
- The specified domain was the Class XII CBSE Physics textbook (Part 1 testing purposes and later extendable to other textbooks)

Software Used

- Used the CDQA suite, a python implementation built upon BERT pretrained on the SQUAD Dataset.

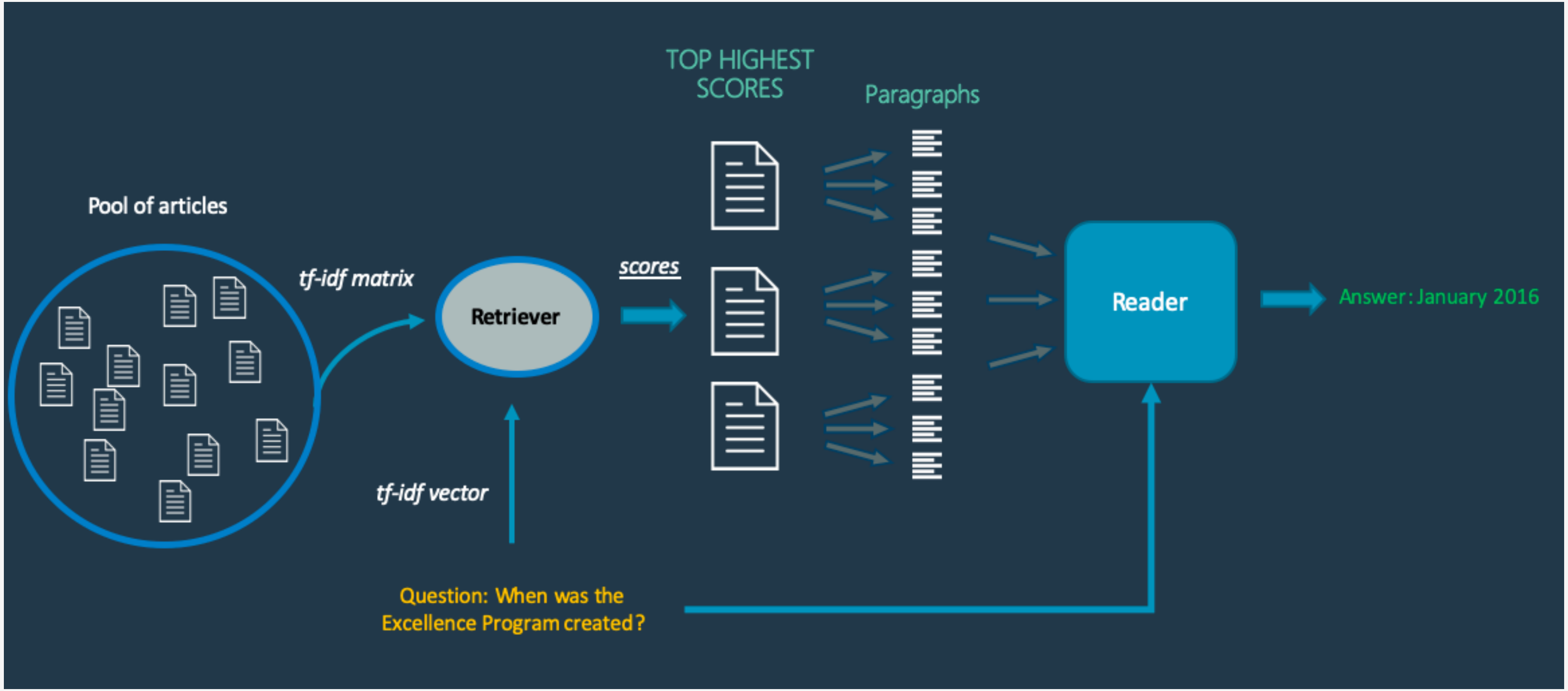
- It has three component parts:

    - cdqa- python package implementing a QA pipeline
    - cdqa-annotator- a tool built to facilitate the annotation of question-answering datasets for model evaluation and fine-tuning
    - cdQA-ui: a user-interface that can be coupled to any website and can be connected to the back-end system.

cdqa

- It is the primary package of the suite.
- It implements a pipeline with the following functions:
  - Fit_retriever – feeds the dataset to the retriever
  - Fit_reader – feeds the annotated .json file to the reader to train/finetune it
  - Predict – predicts the answer to a given question
  - Evaluate_reader – scores the evaluation of the reader
  - Evaluate_pipeline – scores the performance of the reader and the retriever

Design



TOP HIGHEST SCORES
Paragraphs
Pool of articles
tf-idf matrix
Retriever
scores
Reader
Answer: January 2016
tf-idf vector
Question: When was the Excellence Program created?

The Retriever

- Main Function: returns a list of documents in the dataset that are most likely to contain the answer.
- Working:
  - Computes TF-IDF features (Term Frequency Inverse Document Frequency) based on unigrams and bigrams

$$w_{i,j} = tf_{i,j} \times \log\left(\frac{N}{df_i}\right)$$

Where df_i *is number of documents containing i, N is total number of documents and* $tf_{i,j}$ *is number of occurances of i in j*

  - Computes cosine similarity between the question and each document based on those features.
  - After extracting the most probable documents, documents are converted to paragraphs and are sent to the Reader.

The Reader

- PyTorch version BERT model based on HuggingFace's transformer implementation [3].
- The model comes pretrained on the popular SQUAD 1.1 dataset [4](Stanford Question Answering Dataset).
- Model outputs each probable answer it can find to the question in a particular paragraph.
- These are then scored and the best one is outputted.

Work Done I

- Phase I
  - Dataset built by converting pdfs to text files using OCR (Optical Character Recognition) and preprocessed to eliminate bad characters.
  - Done for all eight chapters in the textbook.
  - The processed chapters combined to create the dataset for the model to be trained on.
- Phase II
  - Basic questions queried using the pretrained model on our dataset. Model performed poorly.
  - Concluded that model has to be fine tuned to fit our dataset.
  - Dataset was annotated to generate question-answer pairs to fine tune using the CDQA-annotator. Result imported as .json.

Work Done II

- Phase III
    - The model was then run on the dataset.
    - Dataset converted to a pandas dataframe using paragraph filters, passed to the Retriever using the fit_retriever function. Output passed to the Reader.
    - The Reader trained with the fit_reader function using the annotated dataset, with 3 epochs and 36 iterations.
    - Trained model dumped for testing with new questions.
- Phase IV
    - Pipeline and the Reader evaluated separately, found to have an improved performance after fine-tuning.
- Phase V
    - Entire model bundled into a python FLASK web app using a REST api, built with the CDQA-ui package.
    - Web app tested on localhost:5050

The Code I

```
!pip install cdqa #installs the cdqa library using pip3

from google.colab import drive
drive.mount('/content/drive')

import os
import pandas as pd
from ast import literal_eval

from cdqa.utils.filters import filter_paragraphs
from cdqa.pipeline import QAPipeline

from cdqa.utils.download import download_model

download_model(model='bert-
squad_1.1', dir='./models')      #downloads the pretrained model that was built on that news articles dataset

df = pd.read_csv('./dataset.csv', converters={'paragraphs': literal_eval},encoding="Latin-
1", names=['title','paragraphs'], header=None)
df = filter_paragraphs(df)
df.head()                            #dataset is read and converted into a pandas dataframe
```

The Code II

```
cdqa_pipeline = QAPipeline(reader='./models/bert_qa.joblib')
cdqa_pipeline.fit_retriever(df=df)
#calls the reader  and retriever part of the cdqa lib that parses the dataset

#retriever takes a pool of paragraphs as input and ranks and scores them base
#training the reader
cdqa_pipeline.fit_reader('dataset.json')
cdqa_pipeline.dump_reader('./models/bert_qa.joblib')

query = "What is current density?"
prediction = cdqa_pipeline.predict(query, n_predictions=5)

print('query: {}'.format(query))

from cdqa.utils.evaluation import evaluate_reader

evaluate_reader(cdqa_pipeline, 'dataset.json')

from cdqa.utils.evaluation import evaluate_pipeline

evaluate_pipeline(cdqa_pipeline, 'dataset.json')
```

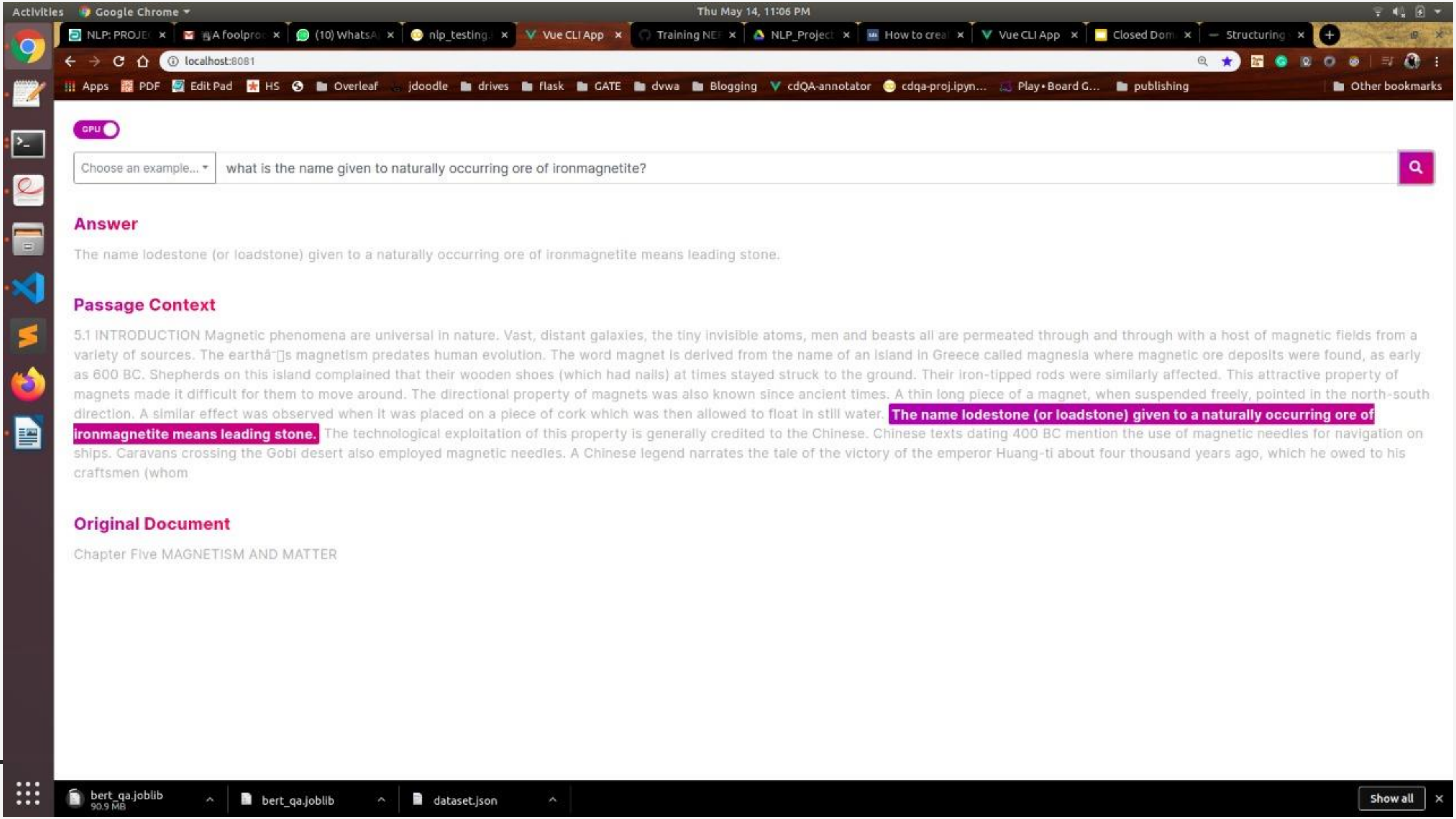
Result

The trained system tested with an f1-score of 0.7599

Further Work

- Retriever currently uses tf-idf features that works based on frequency of a word in a document. This doesn’t scale well for our dataset where the documents are dependent.
- Since increased occurrence of a word may not signify presence of an answer, the Retriever sometimes presents the Reader with an incorrect list of probable documents.
- A new Retriever architecture based on order of documents may solve this issue.

SCREENSHOTS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Choose an example...
what is the name given to naturally occurring ore of ironmagnetite?
Answer
The name lodestone (or loadstone) given to a naturally occurring ore of ironmagnetite means leading stone.
Passage Context
5.1 INTRODUCTION Magnetic phenomena are universal in nature. Vast, distant galaxies, the tiny invisible atoms, men and beasts all are permeated through and through with a host of magnetic fields from a variety of sources. The earthâ□s magnetism predates human evolution. The word magnet is derived from the name of an island in Greece called magnesia where magnetic ore deposits were found, as early as 600 BC. Shepherds on this island complained that their wooden shoes (which had nails) at times stayed struck to the ground. Their iron-tipped rods were similarly affected. This attractive property of magnets made it difficult for them to move around. The directional property of magnets was also known since ancient times. A thin long piece of a magnet, when suspended freely, pointed in the north-south direction. A similar effect was observed when it was placed on a piece of cork which was then allowed to float in still water. The name lodestone (or loadstone) given to a naturally occurring ore of ironmagnetite means leading stone. The technological exploitation of this property is generally credited to the Chinese. Chinese texts dating 400 BC mention the use of magnetic needles for navigation on ships. Caravans crossing the Gobi desert also employed magnetic needles. A Chinese legend narrates the tale of the victory of the emperor Huang-ti about four thousand years ago, which he owed to his craftsmen (whom
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Chapter Five MAGNETISM AND MATTER
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dataset.json
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Choose an example... what is current density?

Answer

A Current per unit area (taken normal to the current), I/A, is called current density and is denoted by j.

Passage Context

I (3.9) A where the constant of proportionality Ï" depends on the material of the conductor but not on its dimensions. Ï" is called resistivity. Using the last equation, Ohmâ□s law reads I Ï"I V =I Ã□R= (3.10) **A Current per unit area (taken normal to the current), I/A, is called current density and is denoted by j.** The SI units of the current density are A/m2. Further, if E is the magnitude of uniform electric field in the conductor whose length is l, then the potential difference V across its ends is El. Using these, the last equation reads R=Ï"

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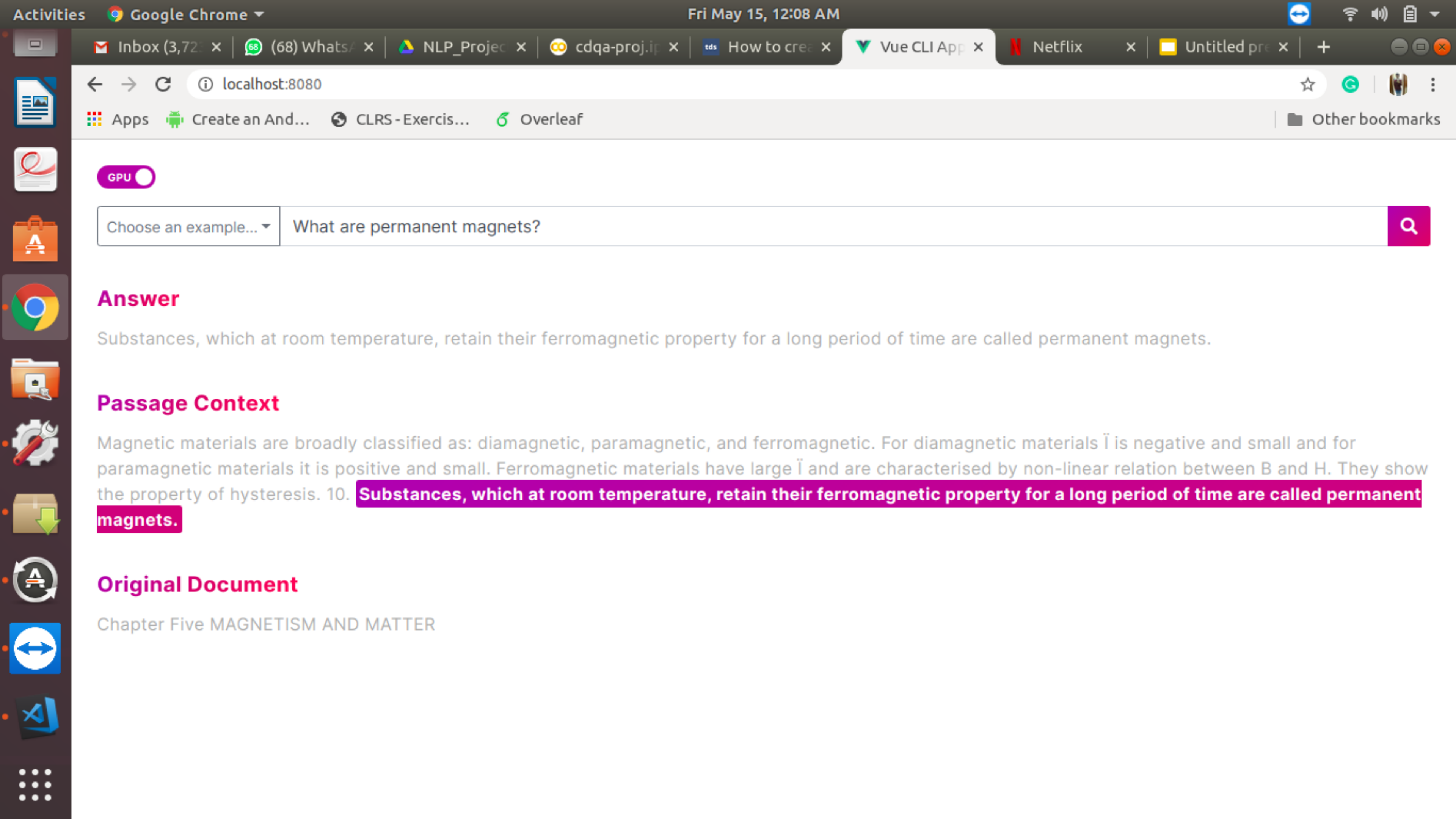
Chapter Three CURRENT ELECTRICITY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Choose an example...
What are permanent magnets?
Answer
Substances, which at room temperature, retain their ferromagnetic property for a long period of time are called permanent magnets.
Passage Context
Magnetic materials are broadly classified as: diamagnetic, paramagnetic, and ferromagnetic. For diamagnetic materials Ï is negative and small and for paramagnetic materials it is positive and small. Ferromagnetic materials have large Ï and are characterised by non-linear relation between B and H. They show the property of hysteresis. 10. Substances, which at room temperature, retain their ferromagnetic property for a long period of time are called permanent magnets.
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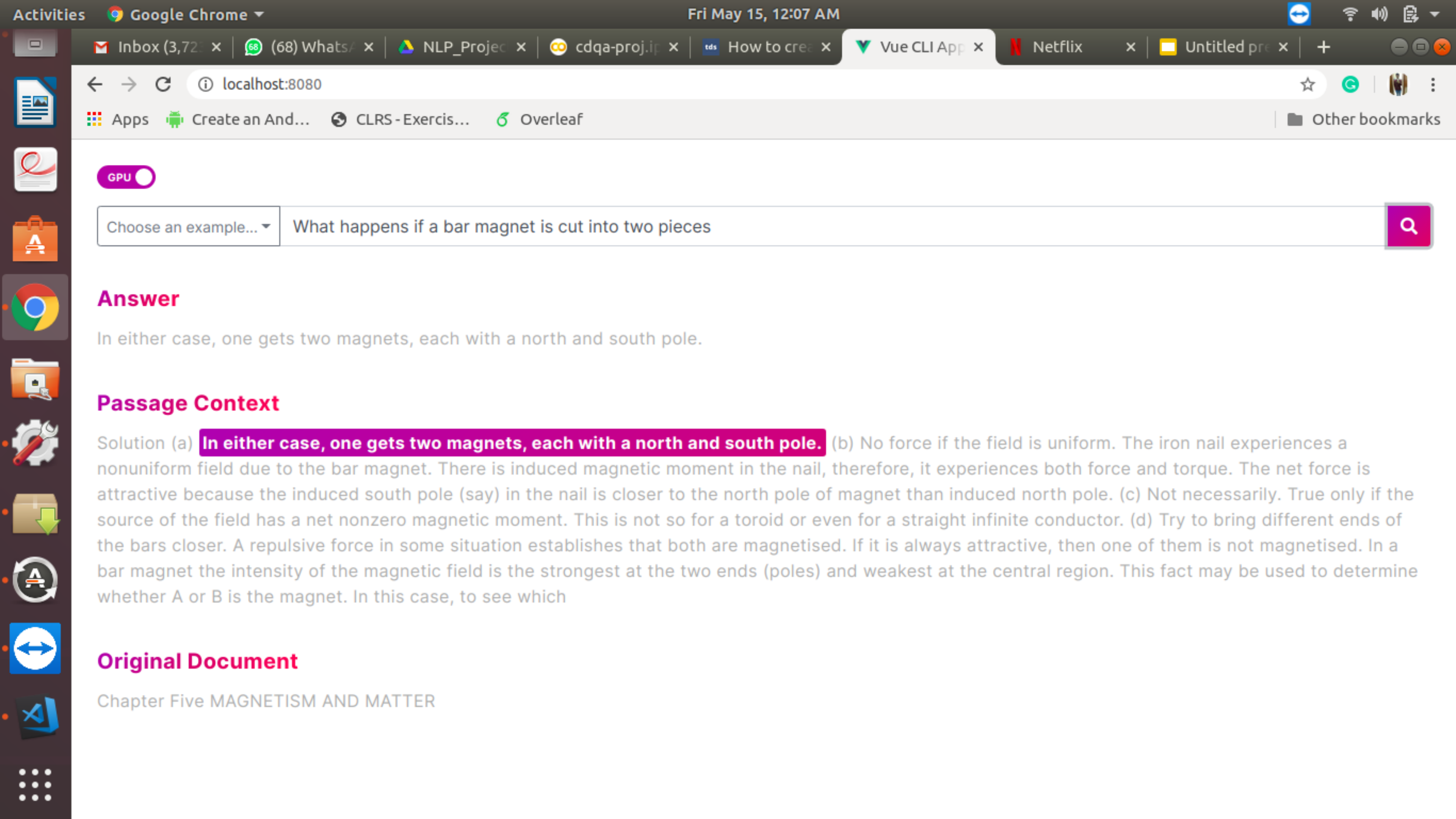
Chapter Five MAGNETISM AND MATTER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Choose an example...
What happens if a bar magnet is cut into two pieces
Answer
In either case, one gets two magnets, each with a north and south pole.
Passage Context
Solution (a) In either case, one gets two magnets, each with a north and south pole. (b) No force if the field is uniform. The iron nail experiences a nonuniform field due to the bar magnet. There is induced magnetic moment in the nail, therefore, it experiences both force and torque. The net force is attractive because the induced south pole (say) in the nail is closer to the north pole of magnet than induced north pole. (c) Not necessarily. True only if the source of the field has a net nonzero magnetic moment. This is not so for a toroid or even for a straight infinite conductor. (d) Try to bring different ends of the bars closer. A repulsive force in some situation establishes that both are magnetised. If it is always attractive, then one of them is not magnetised. In a bar magnet the intensity of the magnetic field is the strongest at the two ends (poles) and weakest at the central region. This fact may be used to determine whether A or B is the magnet. In this case, to see which
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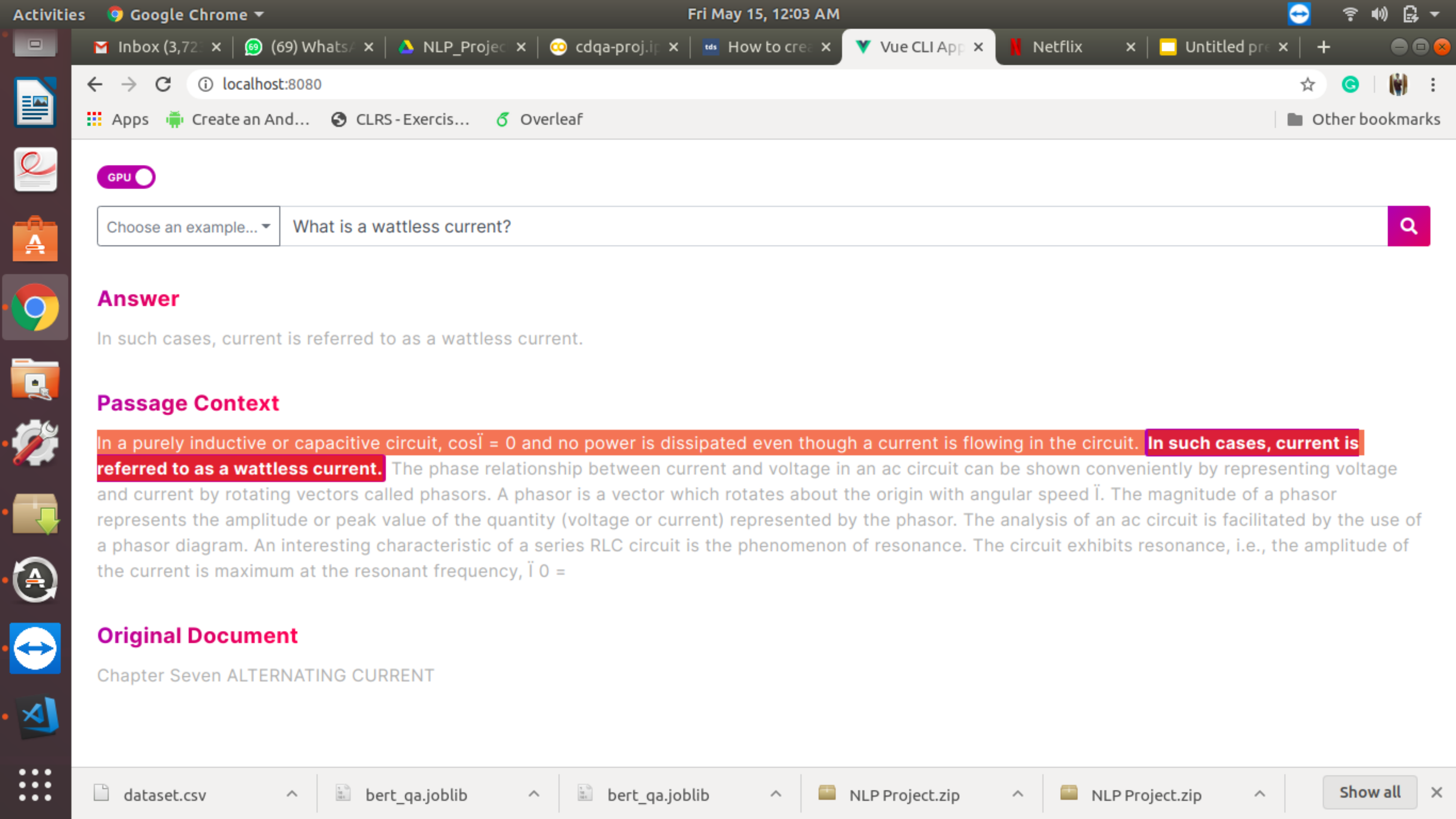
Chapter Five MAGNETISM AND MATTER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Choose an example...
What is a wattless current?
Answer
In such cases, current is referred to as a wattless current.
Passage Context
In a purely inductive or capacitive circuit, cosÏ = 0 and no power is dissipated even though a current is flowing in the circuit. In such cases, current is referred to as a wattless current. The phase relationship between current and voltage in an ac circuit can be shown conveniently by representing voltage and current by rotating vectors called phasors. A phasor is a vector which rotates about the origin with angular speed Ï. The magnitude of a phasor represents the amplitude or peak value of the quantity (voltage or current) represented by the phasor. The analysis of an ac circuit is facilitated by the use of a phasor diagram. An interesting characteristic of a series RLC circuit is the phenomenon of resonance. The circuit exhibits resonance, i.e., the amplitude of the current is maximum at the resonant frequency, Ï 0 =
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Chapter Seven ALTERNATING CURRENT
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Choose an example... | What is the phase angle between the voltage and the current in a resistor?

Answer

the phase angle between the voltage and the current is zero.

Passage Context

7.3 REPRESENTATION OF AC CURRENT AND VOLTAGE BY ROTATING VECTORS â PHASORS In the previous section, we learnt that the current through a resistor is in phase with the ac voltage. But this is not so in the case of an inductor, a capacitor or a combination of these circuit elements. In order to show phase relationship between voltage and current in an ac circuit, we use the notion of phasors. The analysis of an ac circuit is facilitated by the use of a phasor diagram. A phasor* is a vector which rotates about the origin with angular speed Ï, as shown in Fig. 7.4. The vertical components of phasors V and I represent the sinusoidally varying quantities v and i. The magnitudes of phasors V and I represent the amplitudes or the peak values vm and im of these oscillating quantities. Figure 7.4(a) shows the FIGURE 7.4 (a) A phasor diagram for the circuit in Fig 7.1. (b) Graph of v and voltage and current phasors and their i versus Ït. relationship at time t1 for the case of an ac source connected to a resistor i.e., corresponding to the circuit shown in Fig. 7.1. The projection of voltage and current phasors on vertical axis, i.e., vm sinÏt and im sinÏt, respectively represent the value of voltage and current at that instant. As they rotate with frequency Ï, curves in Fig. 7.4(b) are generated. From Fig. 7.4(a) we see that phasors V and I for the case of a resistor are in the same direction. This is so for all times. This means that **the phase angle between the voltage and the current is zero.**

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Choose an example... | Why is AC voltage preferred over DC voltage?

Answer

ac voltages can be easily and efficiently converted from one voltage to the other by means of transformers.

Passage Context

7.1 INTRODUCTION We have so far considered direct current (dc) sources and circuits with dc sources. These currents do not change direction with time. But voltages and currents that vary with time are very common. The electric mains supply in our homes and offices is a voltage that varies like a sine function with time. Such a voltage is called alternating voltage (ac voltage) and the current driven by it in a circuit is called the alternating current (ac current)*. Today, most of the electrical devices we use require ac voltage. This is mainly because most of the electrical energy sold by power companies is transmitted and distributed as alternating current. The main reason for preferring use of ac voltage over dc voltage is that **ac voltages can be easily and efficiently converted from one voltage to the other by means of transformers.** Further, electrical energy can also be transmitted economically over long distances. AC circuits exhibit characteristics which are exploited in many devices of daily use. For example, whenever we tune our radio to a favourite station, we are taking advantage of a special property of ac circuits â⁻ one of many that you will study in this chapter. * The phrases ac voltage and ac current are contradictory and redundant, respectively, since they mean, literally, alternating current voltage and alternating current current. Still, the abbreviation ac to designate an electrical quantity displaying simple harmonic time dependance has become so universally accepted that we follow others in its use. Further, voltage â⁻ another phrase commonly used means potential difference between two points.

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Choose an example... what is lodestone

Answer

The naturally occurring lodestone is another. Such materials form permanent magnets to be used among other things as a compass needle.

Passage Context

ferromagnetic substance of samples. This motion of suspension can be observed. Figure 5.12(b) shows the situation when the domains have aligned and amalgamated to form a single â¨giantâ¨ domain. Thus, in a ferromagnetic material the field lines are highly concentrated. In non-uniform magnetic field, the sample tends to move towards the region of high field. We may wonder as to what happens when the external field is removed. In some ferromagnetic materials the magnetisation persists. Such materials are called hard magnetic materials or hard ferromagnets. Alnico, an alloy of iron, aluminium, nickel, cobalt and copper, is one such material. **The naturally occurring lodestone is another. Such materials form permanent magnets to be used among other things as a compass needle.** On the other hand, there is a class of ferromagnetic materials in which the magnetisation disappears on removal of the external field. Soft iron is one such material. Appropriately enough, such materials are called soft ferromagnetic materials. There are a number of elements, which are ferromagnetic: iron, cobalt, nickel, gadolinium, etc. The relative magnetic permeability is >1000! The ferromagnetic property depends on temperature. At high enough temperature, a ferromagnet becomes a paramagnet. The domain structure disintegrates with temperature. This disappearance of magnetisation with temperature is gradual. It is a phase transition reminding us of the melting of a solid crystal. The temperature of transition from ferromagnetic to paramagnetism is called the Curie temperature Tc. Table 5.4 lists the Curie temperature of certain ferromagnets. The susceptibility above the Curie temperature, i.e., in the paramagnetic phase is described by,

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ANNOTATING

cdQA-annotator

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Chapter Five MAGNETISM AND MATTER

Paragraph 31 of 61 | Document 1 of 2

Magnetism and Matter 0Âº41â⁻² E at Delhi and 0Âº58â⁻² W at Mumbai. Thus, at both these places a magnetic needle shows the true north quite accurately. There is one more quantity of interest. If a magnetic needle is perfectly balanced about a horizontal axis so that it can swing in a plane of the magnetic meridian, the needle would make an angle with the horizontal (Fig. 5.10). This is known as the angle of dip (also known as inclination). Thus, dip is the angle that the total magnetic field BE of the earth makes with the surface of the earth. Figure 5.11 shows the magnetic meridian plane at a point P on the surface of the earth. The plane is a section through the earth. The total magnetic field at P can be resolved into a horizontal component H E and a vertical component ZE. The angle that BE makes with HE is the angle of dip, I.

What is angle of dip?

If a magnetic needle is perfectly balanced about a horizontal axis so that it can swing in a plane of the magnetic meridian, the needle would make an

Add annotation or Delete paragraph

Questions	Answers	Edit
what is angle of dip?	If a magnetic needle is perfectly balanced about a horizontal axis so that it can swing in a plane of the magnetic meridian, the needle would make an angle with the horizontal (Fig. 5.10). This is known as the angle of dip (also known as inclination).	Delete

Previous or Next

Chapter Five MAGNETISM AND MATTER

Paragraph 6 of 61 | Document 1 of 2

Physics (iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field B. In Fig. 5.3(a), B is larger around region ii than in region i . (iv) The magnetic field lines do not intersect, for if they did, the direction of the magnetic field would not be unique at the point of intersection. One can plot the magnetic field lines in a variety of ways. One way is to place a small magnetic compass needle at various positions and note its orientation. This gives us an idea of the magnetic field direction at various points in space.

Type question here...

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Add annotation or Delete paragraph

Questions	Answers	Edit
what are the properties of magnetic field?	(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field B. In Fig. 5.3(a), B is larger around region ii than in region i . (iv) The magnetic field lines do not intersect, for if they did, the direction of the magnetic field would not be unique at the point of intersection.	

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Chapter Five MAGNETISM AND MATTER

Paragraph 7 of 61 | Document 1 of 2

2[(r â x)2 + a 2] 2 The magnitude of the total field is obtained by summing over all the elements â in other words by integrating from x = â l to x = + l . Thus, dx Âµ0nla 2 l â« âl [(r â x)2 + a 2]3 / 2 2 This integration can be done by trigonometric substitutions. This exercise, however, is not necessary for our purpose. Note that the range of x is from â l to + l . Consider the far axial field of the solenoid, i.e., r >> a and r >> l . Then the denominator is approximated by B=

Type question here...

Type answer here...

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Questions	Answers	Edit

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TRAINING

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cdqa-proj.ipynb - Colaboratory | NLP_Project - Google Drive

https://colab.research.google.com/drive/1XqAbYM6acUF0CWeSsLUtfPD

cdqa-proj.ipynb

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```
cdqa_pipeline.fit_reader('dataset.json')
cdqa_pipeline.dump_reader('./models/bert_qa.joblib')
```

```
Could not find answer: '' vs. 'Electric Charges and Fields neutralise or nullify each others effect'
Could not find answer: '' vs. 'the charge on glass rod or cat's fur'
Could not find answer: '' vs. 'the charge on plastic rod or silk'
Could not find answer: '' vs. 'Coulomb's law gives the force between two charges q1 and q2 in vacuum'
Could not find answer: '' vs. 'the principle of superposition says that in a system of charges q1, q2, ..., qn, the force on q1 due to q2 is the same as gi
Could not find answer: '' vs. 'Coulomb's law is consistent with Newton's third law'
Could not find answer: '' vs. 'An electric dipole is a pair of equal and opposite point charges , separated by a distance 2a'
Could not find answer: '' vs. 'The electric field at any general point P is obtained by adding the electric fields by the parallelogram law of vectors'
Could not find answer: '' vs. 'charge q times the separation 2a (between the pair of charges q, -q) and the direction is along the line from -q to q'
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Could not find answer: '' vs. '(i) Gauss's law is true for any closed surface, no matter what its shape or size. (ii) The term q on the right side of Gauss
Could not find answer: '' vs. 'In metallic conductors, these charge carriers are electrons. In electrolytic conductors, the charge carriers are both positi
Could not find answer: '' vs. 'Lightning is a phenomenon in which charges flow from the clouds to the earth through the atmosphere.'
Could not find answer: '' vs. 'The resistance R depends on the material of the conductor and on the dimensions of the conductor.'
Could not find answer: '' vs. 'Electrons move with an average velocity which is independent of time, although electrons are accelerated.'
Could not find answer: '' vs. 'mobility µ is defined as the magnitude of the drift velocity per unit electric field:'
Could not find answer: '' vs. 'Insulators like ceramic, rubber and plastics having resistivities 1018 times greater than metals or more.'
Could not find answer: '' vs. 'They have resistivities characteristically decreasing with a rise in temperature. They are also affected by the presence of
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Could not find answer: '' vs. 'the charge on glass rod or cat's fur'
Could not find answer: '' vs. 'the charge on plastic rod or silk'
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[ ]
```
query = "What is current?"
prediction = cdqa_pipeline.predict(query, n_predictions=5)
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[ ]
```
print('query: {}'.format(query))
for ans in prediction:
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THE END