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PHYSICS
STANDARD LEVEL
PAPER 2

Monday 16 November 2009 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

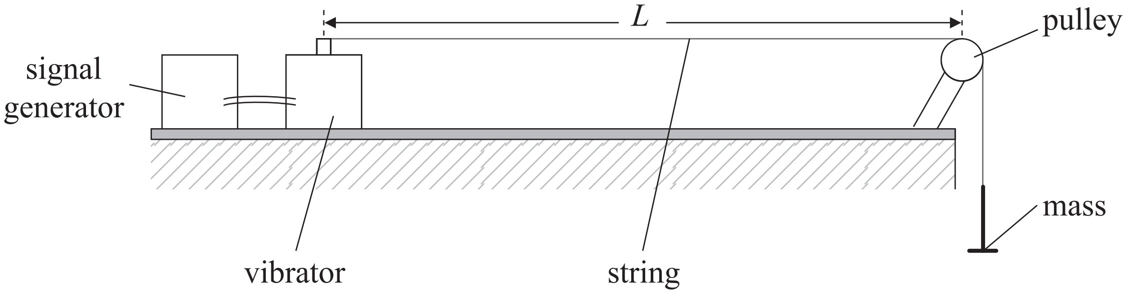
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

SECTION A

*Answer **all** the questions in the spaces provided.*

A1. Data analysis question.

The frequency f of the fundamental vibration of a standing wave of fixed length is measured for different values of the tension T in the string, using the apparatus shown.



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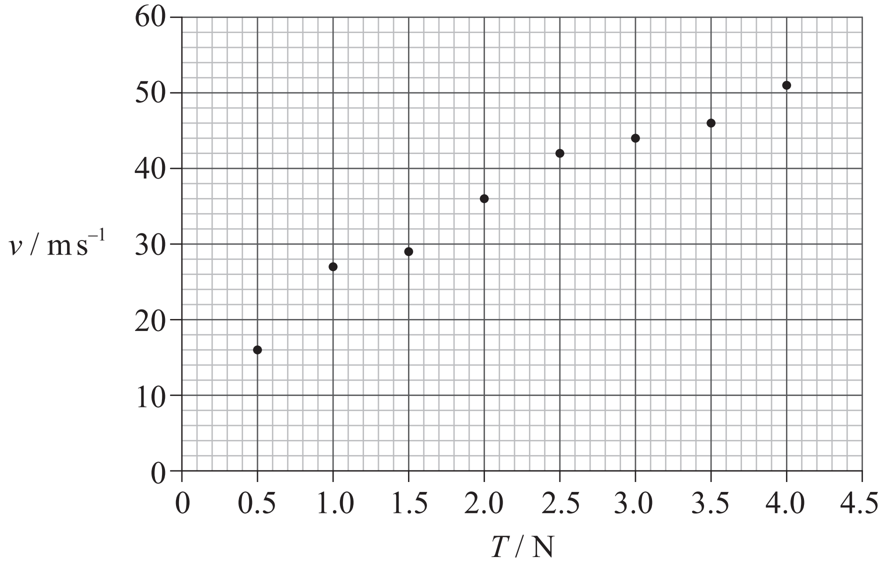
(Question A1 continued)

In order to find the relationship between the speed v of the wave and the tension T in the string, the speed v is calculated from the relation

$$v = 2fL$$

where L is the length of the string.

The data points are shown plotted on the axes below. The uncertainty in v is $\pm 5\,\text{m s}^{-1}$ and the uncertainty in T is negligible.



(a) Draw error bars on the first and last data points to show the uncertainty in speed v. *[1]*

(b) The original hypothesis is that the speed is directly proportional to the tension T. Explain why the data do **not** support this hypothesis. *[2]*

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(This question continues on the following page)

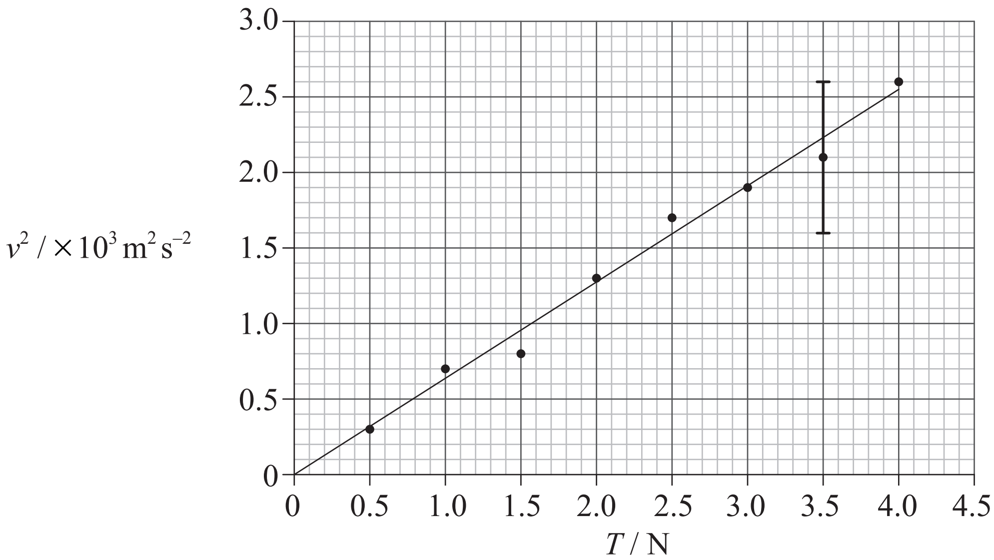
(Question A1 continued)

(c) It is suggested that the relationship between speed and tension is of the form

$$v = k\sqrt{T}$$

where k is a constant.

To test whether the data support this relationship, a graph of v^2 against T is plotted as shown below.



The best-fit line shown takes into account the uncertainties for each data point. The uncertainty in v^2 for $T = 3.5$ N is shown as an error bar on the graph.

(i) State the value of the uncertainty in v^2 for $T = 3.5$ N. *[1]*

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(ii) At $T = 1.0$ N the speed $v = 27 \pm 5$ m s^{-1}. Calculate the uncertainty in v^2. *[3]*

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(Question A1 continued)

(d) Use the graph in (c) to determine *k* without its uncertainty. *[4]*

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A2. This question is about thermal energy transfer.

(a) A piece of copper is held in a flame until it reaches thermal equilibrium. The time it takes to reach thermal equilibrium will depend on the thermal capacity of the piece of copper.

(i) Define *thermal capacity*. *[1]*

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(ii) Outline what is meant by thermal equilibrium in this context. *[1]*

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(b) The piece of copper is transferred quickly to a plastic cup containing water. The thermal capacity of the cup is negligible. The following data are available.

Mass of copper	= 0.12 kg
Mass of water	= 0.45 kg
Rise in temperature of water	= 30 K
Final temperature of copper	= 308 K
Specific heat capacity of copper	= 390 J kg K^{-1}
Specific heat capacity of water	= 4200 J kg K^{-1}

(i) Use the data to calculate the temperature of the flame. *[3]*

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(ii) Explain whether the temperature of the flame is likely to be greater or less than your answer to (b)(i). *[2]*

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A3. This question is about gravitational and electric fields.

(a) The equation for the magnitude of the gravitational field strength due to a point mass may be written as below.

$$Y = \frac{KX}{s^2}$$

The equation for the magnitude of the electric field strength can also be written in the same form.

In the table identify the symbols used in the equation. *[4]*

Symbol	Gravitational field quantity	Electrical field quantity
Y		
K		
X		
s		

(b) The magnitude of the electrostatic force between the proton and electron in a hydrogen atom is F_E. The magnitude of the gravitational force between them is F_G.

Determine the ratio $\frac{F_E}{F_G}$. *[3]*

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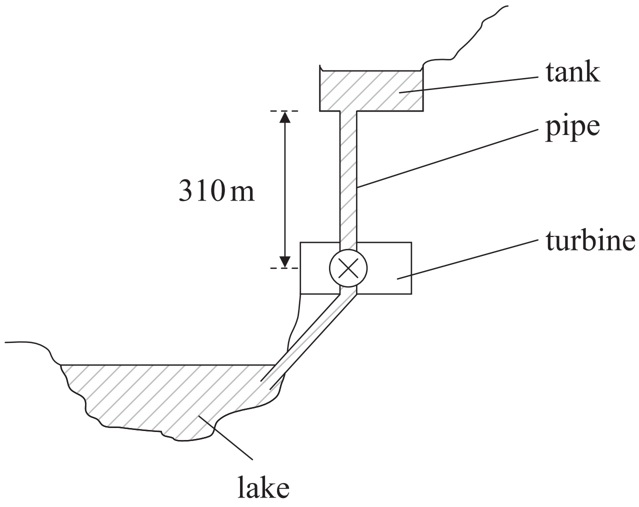
SECTION B

This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about a pumped-storage power station. **Part 2** is about forces and energies.

Part 1 Pumped-storage power station

(a) The diagram, not to scale, shows a pumped-storage power station used for the generation of electrical energy.



Water stored in the tank is allowed to fall through a pipe to a lake via a turbine. The turbine is connected to an electrical generator. The pumped-storage ac generator system is reversible so that water can be pumped from the lake to the tank.

The tank is 50 m deep and has a uniform area of $5.0 \times 10^4\ m^2$. The height from the bottom of the tank to the turbine is 310 m. The density of water is $1.0 \times 10^3\ kg\,m^{-3}$.

(This question continues on the following page)

(Question B1, part 1 continued)

(i) Show that the maximum energy that can be delivered to the turbine by the falling water is about 8×10^{12} J. *[3]*

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(ii) The flow rate of water in the pipe is $400\,\text{m}^3\,\text{s}^{-1}$. Calculate the power delivered by the falling water. *[2]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(b) The energy losses in the power station are shown in the following table.

Source of energy loss	**Percentage loss of energy**
friction and turbulence of water in pipe	27
friction in turbine and ac generator	15
electrical heating losses	5

(i) Calculate the overall efficiency of the conversion of the gravitational potential energy of water in the tank into electrical energy. *[1]*

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(ii) Sketch a Sankey diagram to represent the energy conversion in the power station. *[2]*

(This question continues on the following page)

(Question B1, part 1 continued)

(c) The electrical power produced at the power station is transmitted by cables to the consumer.

(i) Outline how the energy losses in transmission are minimized. *[3]*

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(ii) State **one** advantage and **one** disadvantage that a pumped-storage system has compared to a tidal water storage system. *[2]*

Advantage: . . . .

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Disadvantage: . . . .

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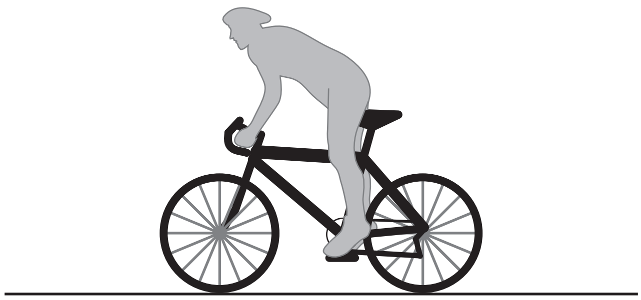
(Question B1 continued)

Part 2 Force and energies

(a) A system consists of a bicycle and cyclist travelling at a constant velocity along a horizontal road.



(i) State the value of the net force acting on the cyclist. *[1]*

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(ii) On the diagram draw labelled arrows to represent the vertical forces acting on the bicycle. *[2]*

(iii) With reference to the horizontal forces acting on the system, explain why the system is travelling at constant velocity. *[2]*

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(This question continues on the following page)

(Question B1, part 2 continued)

(b) The total resistive force acting on the system is 40 N and its speed is 8.0 m s^{-1}. Calculate the useful power output of the cyclist. *[1]*

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(c) The cyclist stops pedalling and the system comes to rest. The total mass of the system is 70 kg.

(i) Calculate the magnitude of the initial acceleration of the system. *[2]*

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(ii) Estimate the distance taken by the system to come to rest from the time the cyclist stops pedalling. *[2]*

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(iii) State and explain **one** reason why your answer to (c)(ii) is only an estimate. *[2]*

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B2. This question is in **two** parts. **Part 1** is about simple harmonic motion. **Part 2** is about electric circuits.

Part 1 Simple harmonic motion

(a) In terms of the acceleration, state **two** conditions necessary for a system to perform simple harmonic motion. *[2]*

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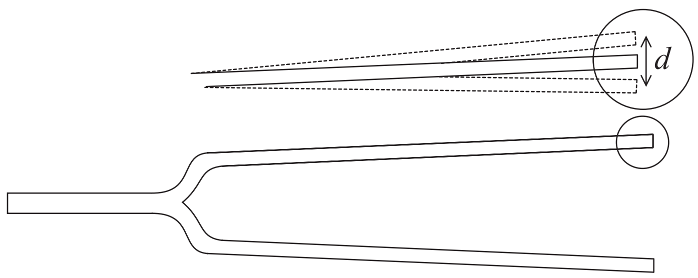
2. . . . .

(b) A tuning fork is sounded and it is assumed that each tip vibrates with simple harmonic motion.



The extreme positions of the oscillating tip of one fork are separated by a distance d.

(i) State, in terms of d, the amplitude of vibration. *[1]*

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(ii) On the axes below, sketch a graph to show how the displacement of one tip of the tuning fork varies with time. *[1]*

(iii) On your graph, label the time period T and the amplitude a. *[2]*

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(Question B2, part 1 continued)

(c) The frequency of oscillation of the tips is 440 Hz and the amplitude of oscillation of each tip is 1.2 mm. Determine the maximum

(i) linear speed of a tip. *[2]*

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(ii) acceleration of a tip. *[2]*

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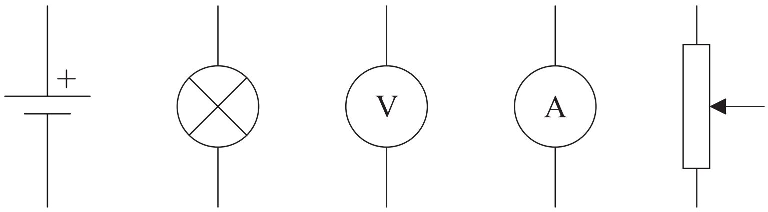
(Question B2 continued)

Part 2 Electric circuits

The components shown below are to be connected in a circuit to investigate how the current I in a tungsten filament lamp varies with the potential difference V across it.



(a) Construct a circuit diagram to show how these components should be connected together in order to obtain as large a range as possible for values of potential difference across the lamp. *[4]*

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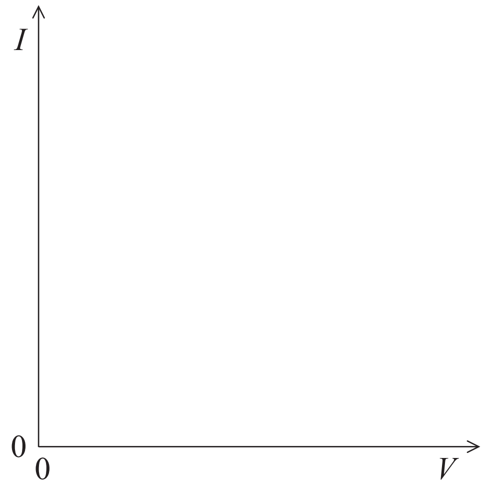
(Question B2, part 2 continued)

(b) On the axes, sketch a graph of I against V for a filament lamp in the range $V = 0$ to its normal working voltage. *[2]*



(c) The lamp is marked with the symbols "1.25 V, 300 mW". Calculate the current in the filament when it is working normally. *[1]*

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(d) The resistivity of tungsten at the lamp's working temperature is $4 \times 10^{-7}\ \Omega\,\text{m}$. The total length of the tungsten filament is 0.80 m. Estimate the radius of the filament. *[4]*

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(e) The cell is connected to two identical lamps connected in parallel. The lamps are rated at 1.25 V, 300 mW. The cell has an emf of 1.5 V and an internal resistance of 1.2 Ω. Determine whether the lamps will light normally. *[4]*

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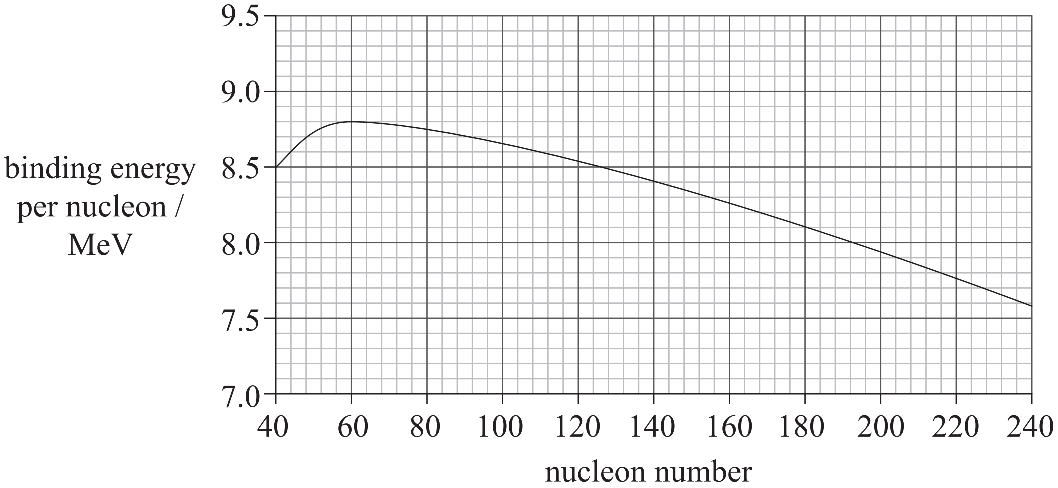
B3. This question is in **two** parts. **Part 1** is about nuclear fission and fusion. **Part 2** is about global warming.

Part 1 Nuclear fission and fusion

(a) The graph shows the variation of binding energy per nucleon for nuclides with a nucleon number greater than 40.



(i) Define *binding energy*. *[1]*

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(ii) On the graph, label with the letter S the position of the most stable nuclide. *[1]*

(iii) State why the nuclide you have labelled is the most stable. *[1]*

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(This question continues on the following page)

(Question B3, part 1 continued)

(b) In a nuclear reactor, a nucleus of uranium(U)-235 fissions into barium(Ba)-141 and krypton(Kr)-92. The equation for this fission is

$$^{235}_{92}\text{U} \rightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + x\,{}^{1}_{0}\text{n}.$$

(i) Use the graph to show that the fission of one nucleus of uranium-235 will release about 200 MeV of energy. *[4]*

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(ii) State the value of x in the equation. *[1]*

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(iii) The mass defect in this reaction is 3.1×10^{-28} kg. Calculate the number of uranium-235 nuclei that must fission in order to release 1.0 kJ of energy. *[2]*

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(iv) Outline how this fission reaction can lead to a chain reaction. *[2]*

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(This question continues on the following page)

(Question B3, part 1 continued)

(c) Intensive scientific effort is devoted to developing nuclear fusion as a future energy source. Discuss what could be the social and environmental benefits of using nuclear fusion as compared with nuclear fission as an energy source. *[3]*

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(Question B3 continued)

Part 2 Global warming

(a) One reason often suggested for global warming is the enhanced greenhouse effect.

(i) State what is meant by the enhanced greenhouse effect. *[1]*

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(ii) State **two** other possible causes of global warming. *[2]*

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2. . . . .

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(This question continues on the following page)

(Question B3, part 2 continued)

(b) One effect of global warming is to melt the Antarctic ice sheet. The following data are available for the Antarctic ice sheet and the Earth's oceans.

Area of ice sheet	$= 1.4 \times 10^7 \text{ km}^2$
Average thickness of ice	$= 1.5 \times 10^3 \text{ m}$
Density of ice	$= 920 \text{ kg m}^{-3}$
Density of water	$= 1000 \text{ kg m}^{-3}$
Area of Earth's oceans	$= 3.8 \times 10^8 \text{ km}^2$

Using the data, determine the

(i) mass of the Antarctic ice. *[2]*

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(ii) change in mean sea level if all the Antarctic ice sheet were to melt and flow into the oceans. *[3]*

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(c) Outline the difference, if any, that the melting of oceanic ice sheets makes to the mean sea level of the Earth. *[2]*

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