St Peter's RC High School

EAT HW One

40 min
40 marks

1. A sign at a railway station advises passengers to keep back from the platform edge. This is because passing trains may cause turbulence.

Explain what is meant by turbulent flow, and suggest why it is dangerous for passengers to stand near the edge of the platform.

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(Total 3 marks)

2. Volcanoes vary considerably in the strength of their eruptions. A major factor in determining the severity of the eruption is the viscosity of the magma material. Magma with a high viscosity acts as a plug in the volcano allowing very high pressures to build up. When the volcano finally erupts it is very explosive. Once magma is out of the volcano it is called lava.

(a) How would the flow of high viscosity lava differ from that of lava with a low viscosity?

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(1)

(b) What would need to be measured to make a simple comparison between the viscosities of two lava flows?

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(1)

(c) When the lava is exposed to the atmosphere it cools rapidly. What effect would you expect this cooling to have on the lava's viscosity?

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(1)

(d) When lava is fast flowing, changes to its viscosity disrupt the flow, making it no longer laminar. Use labelled diagrams to show the difference between laminar and turbulent flow.

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(3)

(e) Different types of lava have different viscosities. The least viscous type has a viscosity of about 1×10^3 Ns m^{-2} whereas a silica-rich lava has a viscosity of 1×10^8 Ns m^{-2}. What type of scale would be used to display these values on a graph?

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(1)

(Total 7 marks)

3. The process of turbulence was described in verse by the British meteorologist, Lewis F. Richardson:

Big whorls have little whorls,
Which feed on their velocity,
And little whorls have lesser whorls,
And so on to viscosity.

Suggest what the author means by the word *whorl.*

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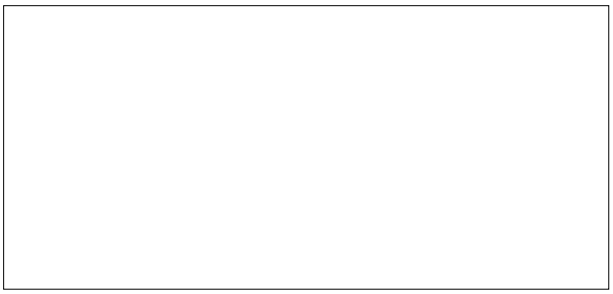
(1)

Draw diagrams in the boxes below to show laminar and turbulent flow.

Describe these flow patterns.

Laminar flow



Description:

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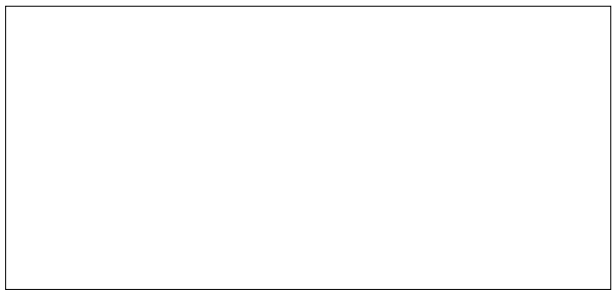
(2)

Turbulent flow



Description:

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(2)

Turbulence can be used to reduce the rate of flow of a fluid.

Explain this statement in terms of energy transfers.

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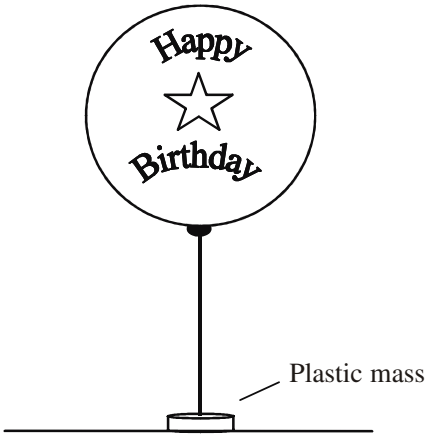
(2)
(Total 7 marks)

4. A child's birthday balloon is filled with helium to make it rise. A ribbon is tied to it, holding a small plastic mass designed to prevent the balloon from floating away.



(a) Add labelled arrows to the diagram of the balloon to show the forces acting on the balloon.

(2)

(b) The balloon is approximately a sphere, of diameter 30 cm. Show that the upthrust on the balloon is about 0.2 N.

The density of the surrounding air $\rho = 1.30$ kg m^{-3}

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(3)

(c) The ribbon is cut and the balloon begins to rise slowly.

(i) Sketch a diagram to show the airflow around the balloon as it rises.

(1)

(ii) What is the name of this type of airflow?

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(1)

(d) A student suggests that if the balloon reaches terminal velocity, its motion could be described by the relationship

$$mg + 6\pi r\eta v = \frac{4}{3}\pi r^3 \rho g$$

where η = viscosity of air, m = mass of the balloon, r = radius of the balloon and v = the terminal velocity reached.

(i) Write the above relationship as a word equation.

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(1)

(ii) The balloon has a total weight of 0.17 N. Use the equation given above to calculate the corresponding value for the terminal velocity of the balloon.

Viscosity of air = 1.8×10^{-5} N s m^{-2}

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Terminal velocity = ...

(3)

(iii) Suggest a reason why the balloon is not likely to reach this calculated velocity.

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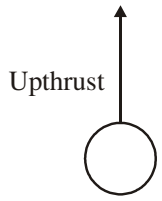
(1)

(Total 12 marks)

5. After wine has been fermenting it contains many small particles. These particles are allowed to settle so that they can be separated from the liquid.

Add labelled arrows to this diagram showing the other two forces on a particle falling downwards within the wine.



(2)

The upthrust can be calculated using the expression $U = \frac{4}{3}\pi r^3 \rho_w g$ where ρ_w is the density of wine and r is the radius of the falling particle.

Explain how the above expression for upthrust is derived.

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(2)

Write down the equation relating the three forces acting on the particle when it reaches terminal velocity.

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(1)

Show that the terminal velocity v of a particle of density ρ_s is given by the following expression:

$$v = \frac{2r^2 g(\rho_s - \rho_w)}{9\eta}$$

where η is the viscosity of the wine.

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(2)

Explain how you would expect the velocity of this particle to change if the temperature of the wine was increased.

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(2)

Stokes's law is valid only provided the flow is laminar. Using a diagram, explain what is meant by the term **laminar flow.**

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(2)
(Total 11 marks)