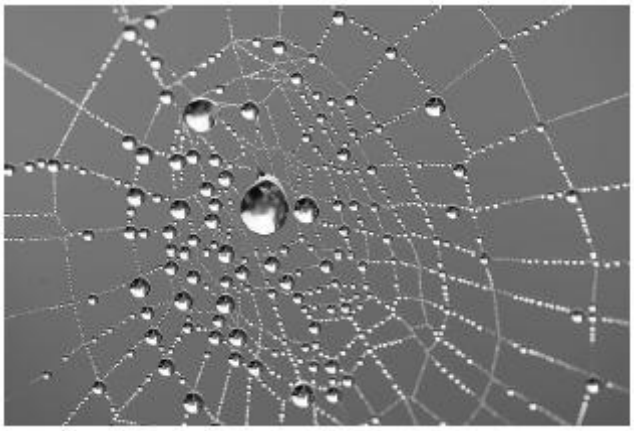
Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Q1.

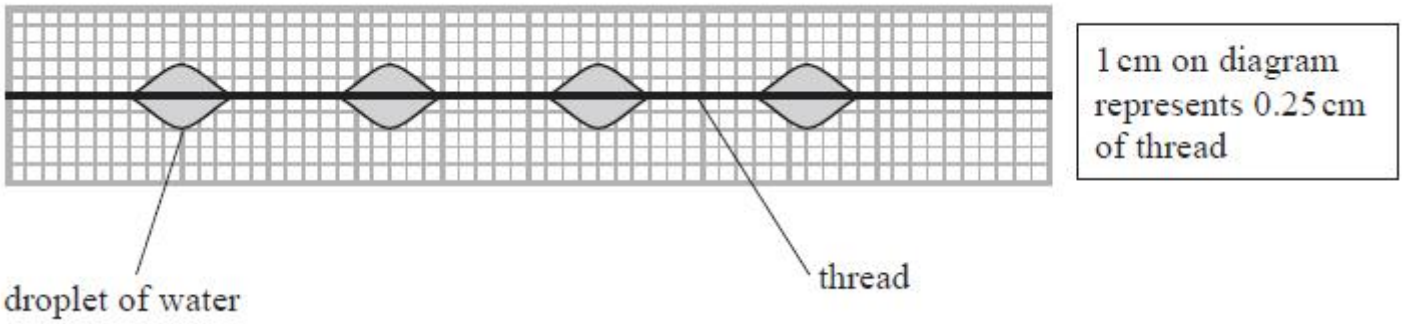
The photograph shows part of a spider's web where water droplets have collected at certain points. The web is made from spider silk which is made by the spider.



Spiders are almost completely dependent on vibrations transmitted through their web for receiving information about the location of trapped insects. When the threads are disturbed by the insects, progressive waves are transmitted along sections of the silk.

It has been suggested that the droplets of water collect at certain points on the web because stationary waves are formed.

The diagram shows water droplets on a single thread of spider silk when the frequency of waves is 7.9 Hz.



Further measurements are taken to test whether the observations are consistent with the presence of stationary waves in the threads.

diameter of the thread = 3.6×10^{-6} m

mass per unit length of the thread = 1.32×10^{-8} kg m^{-1}

Young modulus of spider silk = 1.2×10^{9} N m^{-2}

strain in the thread = 9.7×10^{-9}

Determine, by considering wave speed, whether the measurements are consistent with this suggestion.

(7)

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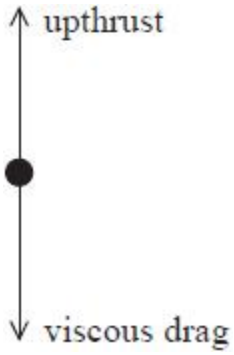
(Total for question = 7 marks)

Q2.

Carbon monoxide gas is produced in a pond by the decay of organic matter.

A bubble of carbon monoxide rises at a steady speed through the still water of the pond. The weight of the bubble is negligible.

The free-body force diagram below shows the forces acting on the bubble.



diameter of bubble = 1.5 mm

(i) Show that the upthrust acting on the bubble is about 1.7×10^{-5} N.

density of water = 997 kg m^{-3}

(3)

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(ii) Calculate the steady speed at which the bubble rises.

viscosity of water = 0.0011 Pa s

(2)

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Speed = ...

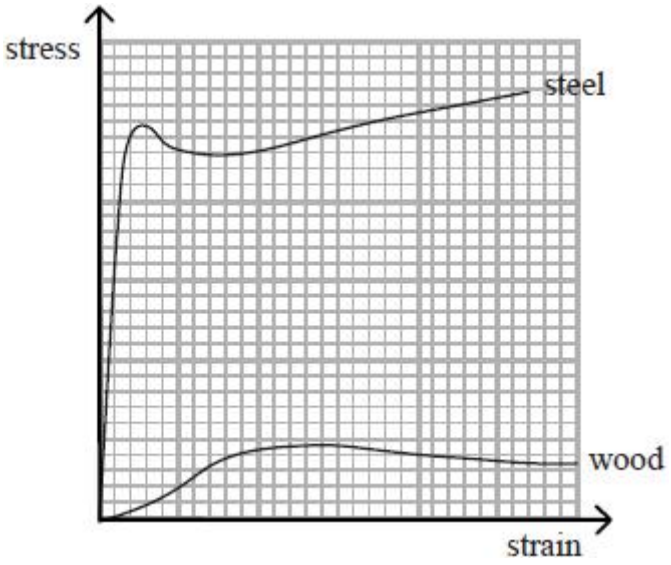
(Total for question = 5 marks)

Q3.

Read the following article and then answer the questions that follow.

"The fastest, tallest and longest dive coaster, on which amusement park thrill seekers can experience free fall, is set to open next summer at Cedar Point in Sandusky, Ohio. Valravn is designed to take riders up to a 66 m peak from which they plummet vertically with an acceleration g and feel weightless.
The advent of steel-frame roller coasters in 1959 made taller structures possible.
Whereas height remains one of the best ways to attain intense speeds, a coaster car can also be shot from its starting point via electromagnetic propulsion or a catapult. Cars on these launched coasters have the potential to go from zero to 130 km h^{-1} in two seconds.
Although coasters can definitely go faster, they're limited by the acceleration those higher speeds would require. Roller coasters reach their peak speeds in a matter of seconds. The achieved acceleration is what causes *g*-forces, which allows riders to feel an increased or decreased sense of their mass. These *g*-forces can be dangerous but they are also well understood by physicists, so roller coasters are built according to strict standards that keep them well within safe levels.
Coasters are only permitted to accelerate up to 6g."
(Source: *Shriek Science: Simple Physics Powers Extreme Roller Coasters Hackett Jennifer, Oct 14, 2015*)

The graph shows typical stress-strain curves for wood and steel.



Discuss how the use of steel, rather than wood, has made the construction of faster and taller roller coasters possible.

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(Total for question = 5 marks)