9.5 Doppler Effect
Hard

PHYSICS

IB HL

9.5 Doppler Effect

Question Paper

Course	DP IB Physics
Section	9. Wave Phenomena (HL only)
Topic	9.5 Doppler Effect
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

A police car passes a stationary car at a speed of 30 m s⁻¹. The police car is 2 m ahead of the car, and 2 m to the left as seen by the driver and emits a continuous tone of frequency 550 Hz.

Which of the following is an expression for the frequency of sound heard by the driver of the car, f'?

A. $550\left(\dfrac{340 - 15\sqrt{2}}{340}\right)$

B. $550\left(\dfrac{340}{370}\right)$

C. $550\left(\dfrac{370}{340}\right)$

D. $550\left(\dfrac{340}{340 + 15\sqrt{2}}\right)$

[1 mark]

Question 2

An alien living in another solar system sends a radio signal of frequency f to the next planet in their solar system. The signal reflects back and is recorded as having a frequency f' which is lower than the original signal.

A few days later they repeat the experiment and find that the frequency change is less than that observed in the first experiment.

Which of the following could cause these effect?

   I. The atmosphere of the planet is rotating such that the radio beam reflects off a section that is moving away from the alien's planet
   II. The planet is moving away from the alien's planet
   III. The atmosphere of the planet is rotating such that the radio beam reflects off a section that is moving towards the alien's planet
   IV. The planet is moving towards the alien's planet

  A. I only

  B. I and II

  C. I and II, followed by II and III

  D. Various combinations of I, II, III and IV

[1 mark]

Question 3

A stationary source emits sound wave with frequency f. An observer moving towards the source measures the sound as having frequency f'. The speed of the observer is 20% of the speed of sound.

What is the the value of f' when the emitted frequency is 10 Hz?

A. 0.8 Hz

B. 1.2 Hz

C. 10.2 Hz

D. 12 Hz

[1 mark]

Question 4

The flow of blood can be monitored using a machine which emits ultrasound of 10 MHz and is then able to measure the change in frequency when the pulse returns having reflected off a red blood cell.

When a wave is reflected from a moving object, the change in frequency is doubled compared to a situation where a sound is detected by a moving observer. Assume that the speed of sound in the body is the same as that of water, $1500 \, \text{m s}^{-1}$.

What is the frequency detected if blood is flowing away at $0.15 \, \text{m s}^{-1}$?

A. 10.002 MHz

B. 2000 Hz

C. 9.998 MHz

D. –2000 Hz

[1 mark]

Question 5

A boat sits on a lake, and is hit by 4 waves every 10 s. As the boat starts to move in the same direction as the waves, exactly 2 waves from behind hit the boat every 10 s. The speed of the boat is $1.5 \, \text{m s}^{-1}$.
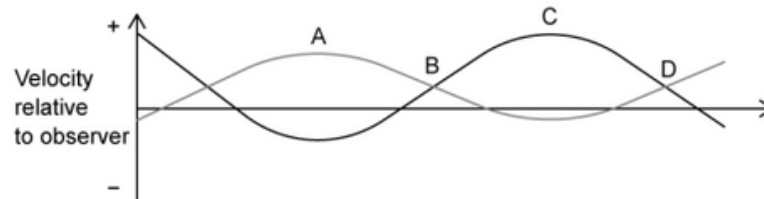
What is the speed of the waves?

A. $1.5 \, \text{m s}^{-1}$

B. $3 \, \text{m s}^{-1}$

C. $1500 \, \text{m s}^{-1}$

D. $340 \, \text{m s}^{-1}$

Question 6

In a binary star system, two stars orbiting each other can be observed using a spectrometer. The star system as a whole is moving away from the Earth at a constant velocity. The spectral lines appear to fluctuate. A graph can be plotted of relative velocity of each star compared to the observer.

(a)
At which point on the graph will the stars be in the following position?
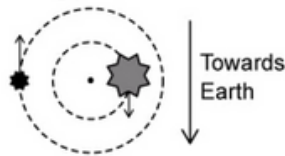
[1 mark]

Question 7

Photographs of lines in the spectrum of the Sun show changes in wavelength. The atmosphere of the sun rotates at a speed u_s, anti-clockwise as observed from its north pole.

What is an expression for the observed change in wavelength λ' of a spectral line from light emitted from the right hand edge of the Sun as viewed from the northern hemisphere on the Earth?

Assume the Earth's orbit is circular.

A. $\lambda' = \lambda \left(1 - \dfrac{u_s}{c}\right)$

B. $\lambda' = \lambda \left(1 + \dfrac{u_s}{c}\right)$

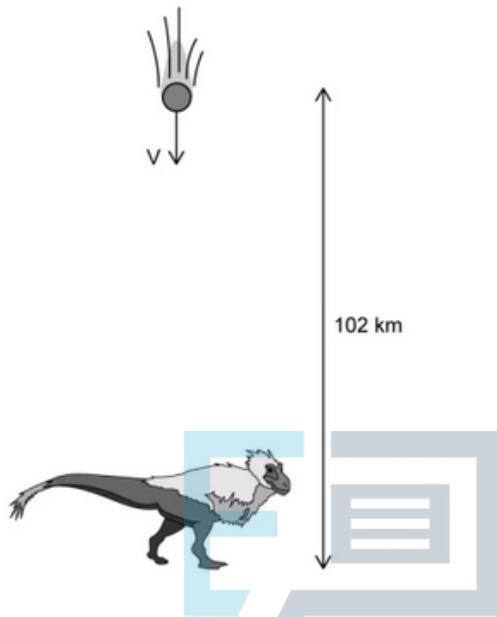C. $\lambda' = \lambda \left(1 - \dfrac{c}{u_s}\right)$

D. $\lambda' = \lambda \left(\dfrac{u_s}{c} - 1\right)$

[1 mark]

Question 8

An asteroid which entered the Earth's atmosphere 64 million years ago emitted a sound of frequency 100 Hz due to the interaction with the atmosphere on its entry.

A T. rex directly under the asteroid hears the noise, but hears it at a frequency of 200Hz. The distance from the top of the atmosphere to the ground is 102 km.
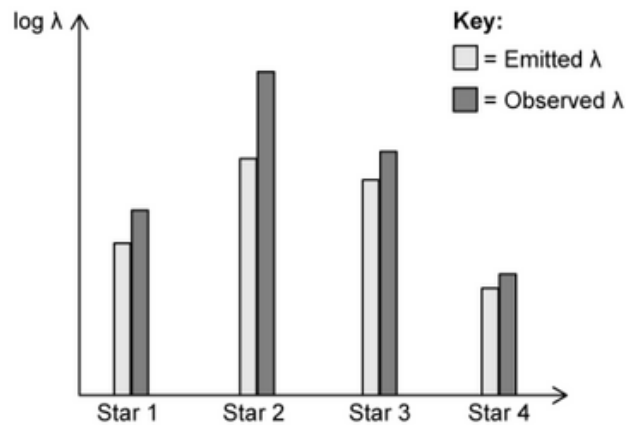

102 km

How long does the T. rex have before the asteroid hits?

A. 10 minutes

B. 170 s

C. 170 mins

D. 6000 s

[1 mark]

Question 9

The graph shows the dominant wavelength of light emitted by 4 different stars, and the same light observed from the Earth.

Which pair of stars are moving away from Earth at the same speed?

A. 1 and 2

B. 2 and 4

C. 3 and 4

D. 1 and 3

[1 mark]

Question 10

A bat is flying towards a tree using echolocation to navigate. The bat emits an ultrasound pulse of 45 kHz. On reflection from the tree, the bat detects a frequency of 50 kHz. The bat is 170 m away from the tree. Due to reflection, the speed of the bat is halved because the Doppler effect is doubled.

How long does the bat have to change course before hitting the tree?

A. 170 s

B. 10 s

C. 5 s

D. 1 s

[1 mark]