FULLY STRUCTURED SOLUTION TO ITEM 2 (WAVES & TELEVISION PHYSICS QUESTION)

Given Data:
Amplitude, $A = 10$ cm
Wavelength, $\lambda = 200$ cm
Wave speed, $v = 100$ cm s^{-1}
Wave travels from left to right.
At t = 0 s, the left end is at origin and moving downward.

(a) Helping the student understand all that confused him

(i) Wave front
A wave front is an imaginary line or surface joining all points on a wave which are vibrating in the same phase at a given instant. All particles on one wave front have the same displacement and move in the same direction.

(ii) Ray
A ray is an imaginary straight line drawn perpendicular to a wave front. It shows the direction in which the wave or energy travels.

(iii) Optical path
Optical path is the effective or apparent distance travelled by light in a medium. It is given by:
Optical path = refractive index × actual path length.

(iv) Huygen's construction on reflection
According to Huygen's principle, every point on an incident wave front acts as a source of secondary wavelets. When the wave front strikes a reflecting surface, these wavelets are reflected and the common tangent drawn to them forms the reflected wave front. This construction proves that angle of incidence equals angle of reflection.

(v) How he was able to see what was in the studio
Light reflected from objects in the studio entered the television camera. The camera converted the light information into electrical signals. These signals were transmitted as electromagnetic waves to the television receiver where they were converted back into visible images on the screen. The student then saw the picture.

(vi) How he was able to hear what was in the studio
Sound waves from the musician and guitar were converted by a microphone into electrical signals. These signals were transmitted to the television receiver. The loudspeaker in the TV converted the signals back into sound waves which travelled through air to the student's ears.

(b) Angular frequency of the wave

Using $v = f\lambda$
$100 = f(200)$
$f = 0.5$ Hz

Angular frequency, $\omega = 2\pi f = 2\pi(0.5) = \pi$ rad s^{-1}.
Therefore, ω **=** π **rad** $\mathbf{s^{-1}}$.

(c) Equation of motion of the progressive wave

General equation: $y = A \sin(kx - \omega t + \phi)$
Wave number, $k = 2\pi/\lambda = 2\pi/200 = \pi/100$.
Hence $y = 10 \sin[(\pi/100)x - \pi t + \phi]$.
At x = 0 and t = 0, y = 0, therefore $\phi = 0$ or π.

Since the left end is moving downward, transverse velocity must be negative, therefore $\phi = 0$.
Hence:
$y = 10 \sin[(\pi x/100) - \pi t]$.

(d) Equation of motion of the left end of the string

At the left end, $x = 0$.
Therefore $y = 10 \sin(0 - \pi t)$
$y = -10 \sin \pi t$.
Hence:
$y = -10 \sin \pi t$.

(e) Equation of motion of a particle 150 cm to the right of origin

At $x = 150$ cm,
$y = 10 \sin[(\pi/100)(150) - \pi t]$
$y = 10 \sin(3\pi/2 - \pi t)$
Since $\sin(3\pi/2 - \pi t) = -\cos \pi t$,
Therefore:
$y = -10 \cos \pi t$.

(f) Magnitude of maximum velocity of any particle on the string

Maximum particle velocity in SHM is given by:
$v_{max} = A\omega$
$= 10 \times \pi$
$= 10\pi$ cm s^{-1}
≈ 31.4 cm s^{-1}.
Therefore:
$v_{max} = 10\pi$ cm s^{-1}.