A 150-g mass is attached to a horizontal spring. It oscillates at a frequency of 1.5 Hz. At a certain instant, the mass is at x = 4.0-cm and has v_x = - 20 cm/s. Determine:

a) The period.
b) The amplitude.
c) The maximum speed.
d) The total energy.

Given:

Mass attached to the spring:	m = 150-g = 0.15-kg
Frequency of oscillation:	f = 1.5 Hz
Displacement of mass at a certain instant:	x = 4.0-cm = 0.04-m
Velocity of mass at x =4.0-cm:	v_x = - 20 cm / s = - 0.20 m/s

Determine:

a) The period of oscillation: T

Use formula:

$T = 1 / f$ ---------------------(1)

Substituting for f in (1):

T = 1 / 1.5 = 0.67 s

b) The amplitude of oscillation: A

Use equation:

Total energy (E) = Potential Energy (U) + Kinetic Energy (K) --------(2)

$$E = (\tfrac{1}{2})kA^2 = (\tfrac{1}{2})mv_{max}^2 \text{ ------------------------(3)}$$

$$U = (\tfrac{1}{2})kx^2 \text{ --(4)}$$

$$K = (\tfrac{1}{2})mv_x^2 \text{ --------------------------------------(5)}$$

When the displacement of oscillation is maximum (x = A), speed at this point of oscillation is zero. Then total energy of the system equals the potential energy of the system and kinetic energy is zero.

When displacement is zero, the speed at this point of oscillation is maximum. Then total energy of the system equals the kinetic energy of the system and potential energy is zero.

Substituting in (2) from (3), (4) & (5) :

$$(\tfrac{1}{2})kA^2 = (\tfrac{1}{2})kx^2 + (\tfrac{1}{2})mv_x^2 \text{ ------------------------(6)}$$

Spring constant "k" needs to be determined first.

Use formula:

$$f = (1 / 2\pi) \times (k / m)^{1/2} \text{ ------------------(7)}$$

Rearranging (7) and substituting for f & m in (7):

$$k = 4\pi^2 f^2 m = 4 \times (3.14)^2 \times (1.5)^2 \times 0.15 = 13 \text{ N / m}$$

Simplifying (6) & substituting for k, x, m & v in (6):

$$A^2 = (kx^2 + mv_x^2) / k = [(13 \times (0.04)^2) + (0.15 \times (-0.20)^2)] / 13 = 0.0021 m^2$$

$$\mathbf{A = 0.046\ m = 4.6\ cm}$$

c) Maximum speed of the oscillation: v_{max}

Use equation (3):

$$(½)kA^2 = (½)mv_{max}^2$$

Simplifying & rearranging (3), & substituting for k, A and m in (3):

$$\mathbf{v_{max} = A \times (k / m)^{1/2} = 0.046 \times (13 / 0.15)^{1/2} = 0.43\ m/s}$$

d) Total energy of the oscillation: E

Use equation (3):

$$E = (½)kA^2$$

Substituting for k, & A in (3):

$$\mathbf{E = (½) \times 13 \times (0.046)^2 = 0.0137\ J}$$