Question Number	Answer		Mark
19(a)	Use of $T = \frac{t_{\text{mean}}}{30}$ [t_{mean} = 13.675 s]	(1)	4
	Use of $T = 2\pi\sqrt{\frac{m}{k}}$ [Allow use of $\omega^2 = \frac{k}{m}$ with $T = \frac{2\pi}{\omega}$]	(1)	
	Use of factor of 2 applied to either *m* or *k*	(1)	
	k = 20.9 (N m^{-1}), so label is correct.	(1)	
	Example of calculation $T = \frac{(13.65 + 13.70)/2}{30} = 0.456\text{ s}$ $0.456\text{ s} = 2\pi\sqrt{\frac{0.22\text{ kg}}{k}}$ $\therefore k = \frac{4\pi^2 \times 0.22\text{ kg}}{(0.456\text{ s})^2} = 41.8\text{ N m}^{-1}$ $k = \frac{41.8\text{ N m}^{-1}}{2} = 20.9\text{ N m}^{-1}$		
19(b)(i)	When the driving frequency is equal to the natural frequency of the mass-spring system	(1)	3
	Resonance occurs	(1)	
	There is a maximum transfer of energy (to the mass-spring system and the amplitude increases)	(1)	
	[Allow spring for mass-spring system]		
19(b)(ii)	Some of the energy from the student's hand is transferred to the oscillating mass **and** some of the energy is transferred to surroundings	(1)	3
	When the amplitude is a maximum, minimum energy is transferred to surroundings [Accept "at the natural frequency" or "resonance" for when the amplitude is a maximum]	(1)	
	. (In a closed system) total energy is constant so the student is incorrect. **Or** She is incorrect as energy is always conserved (in a closed system)	(1)	
	Total for question 19		**10**