Question Number	Answer	Mark
19(a)	Use of $\Delta W = F\,\Delta x$ **or** $\Delta E_{grav} = mg\Delta h$ **(1)** Use of $P = W / t$ **(1)** Use of efficiency = useful power output / total power input **Or** Use of efficiency = useful energy output / total energy input **(1)** Total power input = 2.0×10^4 W **(1)** <u>Example of calculation</u> $\Delta W = 4.4 \times 10^4 \times 15$ m $= 6.6 \times 10^5$ J Output power = 6.6×10^5 J ÷ 70 s = 9.4×10^3 W Efficiency = $\frac{9.4\times10^3\ \text{W}}{\text{Total power input}} = 0.47$ Total power input = $\frac{9.4 \times 10^3\ W}{0.47} = 2.0 \times 10^4$ W	**4**
19(b)(i)	Total clockwise must balance total anticlockwise moment (about tower) **Or** Net/resultant/total moment (about tower) must be zero. **(1)** Total anticlockwise moment is due to counterweight **and** Total clockwise moment is due to sum of moment from beam and load **(1)** Increasing the distance of the load increases the (cw) moment (distance of CoG remains the same) **(1)** Distance of counterweight needs to be increased [dependent on MP3] **(1)**	**4**

19(b)(ii)	Use of moment = $F\,x$	**(1)**	
	Position of centre of mass of beam identified	**(1)**	
	Use of principle of moments	**(1)**	
	Maximum distance of load = 15 m **Or, for load at 22 m …** CW moment =1.18×10^6 Nm **and** max ASW moment = 8.8×10^5 Nm **Or** Required distance of counterweight = 11 m **Or** Required counterweight = 1.5×10^5 N **Or** Maximum load = 3.0×10^4 N **Or** Required distance to CoG = 2.9 m **Or** Required weight of beam = 1.3×10^4 N **Or** Resultant moment = 3.0×10^5 Nm (cw)	**(1)**	
	Valid conclusion by comparison of relevant student values	**(1)**	**5**
	<u>Example of calculation</u> For equilibrium: 3.0×10^4 N × 7.0 m + 4.4×10^4 N × x = 1.1×10^5 N × 8.0 m where x is the maximum distance of the load from the tower. x = (8.8×10^5 Nm − 2.1×10^5 Nm) ÷ 4.4×10^4 N = 6.7×10^5 Nm ÷ 4.4×10^4 N = 15.2 m 15.2 m < 22.0 m so crane would topple if load moved to end of beam		
	Total for question 19		**13**