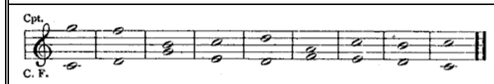
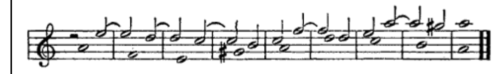
Example written explanations of qualitative reasoning: Scaffolds of argumentation have corresponding parts that can be used to analyze five species of argument structure

Toulmin, S.E., *The Uses of Argument*, Cambridge University Press (1958).	**CER** McNeill, K.L., Lizotte, D.J., Krajcik, J., and Marx, R.W., "Supporting students' construction of scientific explanations by fading scaffolds in instructional materials", *J. Learn. Sci.*, **15**,153-191 (2006). doi:10.1207/s15327809jls1502_1 — Style 1	Style 2	**ABCD** Frensley, J., "ABCD's of explaining your reasoning," *Phys. Teach.*, **57**, 202-203 (March 2019). doi:10.1119/1.5092492	**REASoN**	**1st species**	**2nd species**	**3rd species**	**4th species**	**5th species**
									
					Simple pairings	**Analyze** constancy and change with more or less detail		**Argue from contradiction**	
					Use **substitution** / **transitive property** to show that two quantities have equal value	**Qualitatively** analyze by distinguishing among broad categories of increase, decrease, remain the same	**Quantitatively** analyze by using algebraic symbols (e.g. exponents) to distinguish among subcategories (e.g. increasing by doubling vs. increasing by quadrupling)	Describe a **conflict** that would occur in a hypothetical scenario and a **resolution** of the conflict	**Combine**
Backing (authority of warrant)	**E**vidence	**R**easoning	**B**asic principles	**R**elationship	According to N2L,	According to N2L,	According to the definition of kinetic energy,	According to N2L,	
Warrant (rule, relationship, or tool used to get from data to claim)					$a_y = \frac{\sum F_y}{m_\mathrm{I}}$.	$a_x = \frac{\sum F_x}{m}$.	$K = \frac{1}{2}mv^2$, an object's kinetic energy is proportional to the object's mass and proportional to the square of the object's speed.	the net inward force $\sum F_\mathrm{IN}$ (provided by the gravitational force, $F_\mathrm{G} = \frac{GMm}{r^2}$, which is inversely proportional to r^2) equals the product $m \cdot \frac{v^2}{r}$ (which is inversely proportional to r) of the mass of the moon m and radially inward acceleration $a_\mathrm{IN} = \frac{v^2}{r}$.	
Data/Grounds		**E**vidence	**C**onnect to situation (**c**ompare, **c**ontrast, **c**ite)	**E**qual/same	The net y-force equals $F_\mathrm{G} = m_\mathrm{G} g$.	The mass of the object was the same in both experiments.	The mass of the object was the same in both experiments.	The masses are the same in both scenarios. If the speed v also stayed unchanged	
				Altered/different		The net force was stronger in the 2nd experiment.	The speed of the object in the 2nd experiment was double the speed of the object in the 1st experiment.	even while the distance r between the center of the planet and the center of the small moon were increased,	
Claim	**R**easoning	**C**laim	**D**raw ideas together into assertion	**So** what?	So, the y-acceleration $a_y = \frac{m_\mathrm{G} g}{m_\mathrm{I}}$ equals the ratio of the product of the object's gravitational mass and the gravitational acceleration to the object's inertial mass.	So, the magnitude of the acceleration was greater in the 2nd experiment.	So, the kinetic energy of the object was quadrupled in the 2nd experiment.	both the gravitational force expression $\frac{GMm}{r^2}$ and the product $m \cdot \frac{v^2}{r}$ of mass and acceleration would have smaller magnitude, but the gravitational force expression would have smaller magnitude than the product of mass and acceleration.	
	Claim		**A**nswer / **A**ssertion					So, to keep the gravitational force expression $\frac{GMm}{r^2}$ and the product $m \cdot \frac{v^2}{r}$ of mass and acceleration equal, the speed v must also decrease.	
				Any quantity to analyze **N**ext?					↺

Counterpoint excerpts from Lehmann, F.J., *A Treatise on Simple Counterpoint in Forty Lessons*. G. Schirmer, New York: 1907, available at https://www.gutenberg.org/files/16342/16342-h/16342-h.htm