1. [10 points] A model[1] for the extinction rate of marine species during the Phanerozoic period (which extends from approximately 545 million years before the present until now) stipulates that this extinction rate, $r(t)$, in numbers of marine animal families per million years, is

$$r(t) = \frac{3130}{t + 262},$$

where t is the number of million years after the start of the Phanerozoic period.

a. [5 points] Find an expression for $E(t)$, the number of extinctions that occurred between the start of the Phanerozoic period and t million years thereafter.

Solution: Using the fundamental theorem of calculus, this is just

$$E(t) = \int_0^t \frac{3130}{x + 262}\, dx = \left(3130 \ln|x + 262|\right)\Big|_0^t = 3130 \ln(t + 262) - 3130 \ln(262).$$

(units are marine animal families).

b. [5 points] Find an expression for the average rate of extinctions between the start of the Phanerozoic period and t million years thereafter.

Solution: The average rate is

$$A(t) = \frac{1}{t - 0} \int_0^t \frac{3130}{x + 262}\, dx = \frac{1}{t} \left(3130 \ln(t + 262) - 3130 \ln(262)\right).$$

(units are marine animal families/million years).

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[1]Newman & Eble, *Decline in Extinction Rates and Scale Invariance in the Fossil Record*, Paleobiology **25**:234–39 (1999)