



## **Second-order bound and free waves for a narrow-banded surface gravity wave group propagating over an infinite step**

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Narrow-banded wave theory correct to second order in wave steepness is extended to the case in which the depth changes abruptly (a step). Thus, a complex set of bound waves consisting of self and cross interactions among incoming, reflected, transmitted, and evanescent waves, are revealed in the region local to the step, which have the potential to change local wave statistics. Unlike the problem without a step, second-order sub- and super-harmonic free waves are generated. The generation of sub-harmonic free waves at second-order, which take the form of a depression or an elevation of the wave-averaged free surface (and a mean flow underneath), is a feature particular to a wave group. It cannot arise for monochromatic waves. These sub-harmonic free waves are long and sometimes called infra-gravity waves due to their lower frequency. We thus describe explicitly the mechanism responsible for their generation when wave groups meet the coast for the idealized case of an abrupt step.