Signals and datasets that arise in physical and engineering applications, as well as social, genet-
ics, biomolecular, and many other domains, are becoming increasingly larger and more complex.
In contrast to traditional time and image signals, data in these domains are supported by arbi-
trary graphs. Signal processing on graphs extends concepts and techniques from traditional signal
processing to data indexed by generic graphs. This abstract studies the concepts of low and high
frequencies on graphs, and low-, high-, and band-pass graph filters. In traditional signal process-
ing, there concepts are easily defined because of a natural frequency ordering that has a physical
interpretation. For signals residing on graphs, in general, there is no obvious frequency ordering. I
introduce a definition of total variation for graph signals that naturally leads to a frequency order-
ing on graphs and defines low-, high-, and band-pass graph signals and filters. I study the design
of graph filters with specified frequency response, and illustrate our approach with applications to
sensor malfunction detection and data classification.

In addition to the frequency analysis, I also introduce a sampling theory for signals that are
supported on either directed or undirected graphs. The theory follows the same paradigm as clas-
sical sampling theory. I show that the perfect recovery is possible for graph signals bandlimited
under the graph Fourier transform, and the sampled signal coefficients form a new graph signal,
whose corresponding graph structure is constructed from the original graph structure, preserv-
ing frequency contents. By imposing a specific structure on the graph, graph signals reduce to
finite discrete-time signals and the introduced sampling theory works reduces to classical signal
processing.