

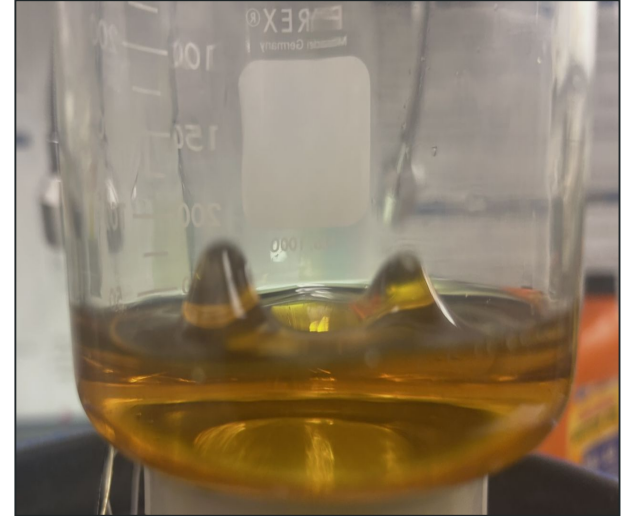
How Viscosity Controls Wave Onset: Tracking Faraday Instabilities in Oils

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Background

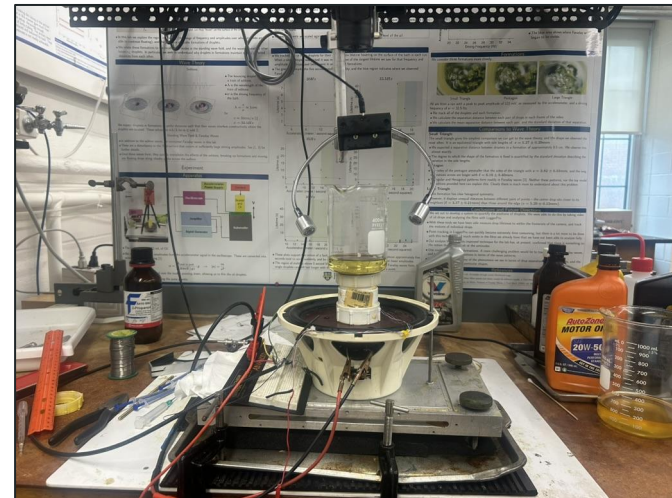
- Faraday instability occurs when the flat surface of a liquid in a vertically vibrating container becomes unstable and forms a regular pattern of standing waves (Faraday waves).
- This occurs when the amplitude and frequency of the vertical oscillation exceed a critical threshold.
- When driving acceleration is turned up high enough, there are large periodic ripples that will appear on the surface of oil. This indicates that the liquid has been driven with enough force to cause the boundary between the two substances to become unstable.
- Viscosity is a natural damping mechanism that keeps the oil undisturbed till enough force is applied.
- Once the critical acceleration for wave formation is met for some viscosity, Faraday instability is observed.

We theorize that the more viscous the oil, the higher the threshold of acceleration to observe Faraday waves.

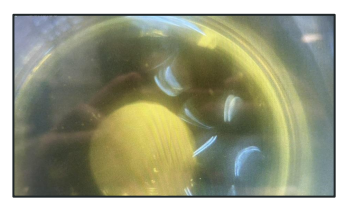
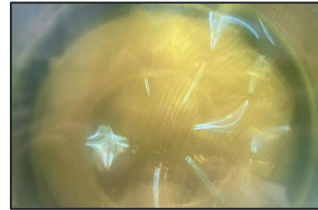
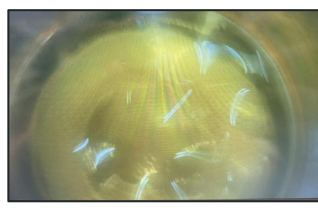
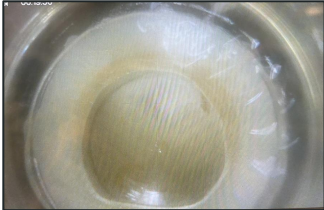


Set-up and Procedure

- Amplifier set to 500mV and maximum current output of 5A.
- The driving frequency was initially set to 30Hz, but moved to 15Hz for to collect more data points.
- Amplitude slowly increased until the desired Faraday waves appeared on the surface of the oil.
- Data was then collected for frequencies from 15 to 45Hz at 5Hz increments.
 - The amplifier was reset to 500mV-1V between each trial so that the oil could return to its undisturbed state.



Oils

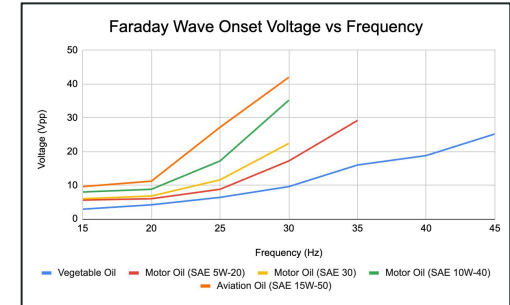
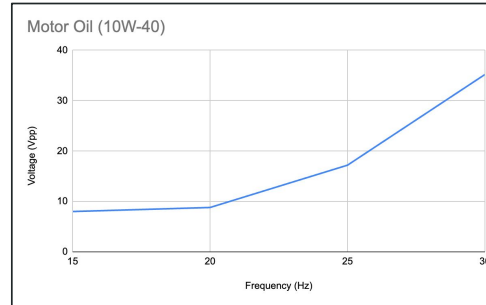
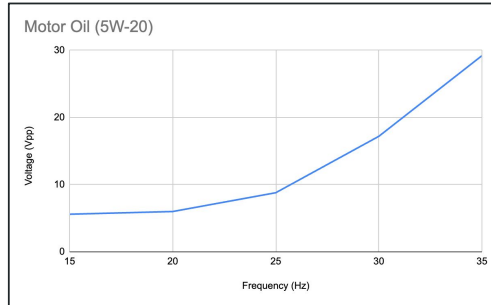
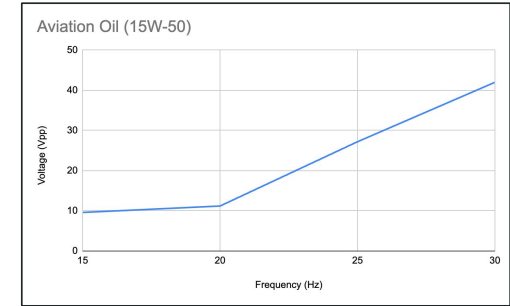
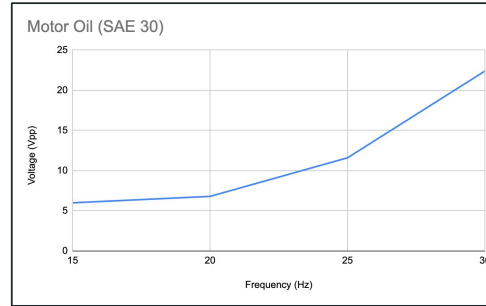
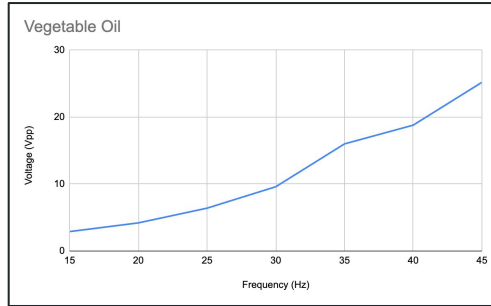


Data

	Voltage (V)				
Frequency	Vegetable Oil	Motor Oil (SAE 5W-20)	Motor Oil (SAE 30)	Motor Oil (SAE 10W-40)	Aviation Oil (SAE 15W-50)
15	2.9	5.6	6.0	8.0	9.6
20	4.1	6.0	6.8	8.8	11.2
25	6.4	8.8	11.6	17.2	27.2
30	9.6	17.2	22.4	35.2	42
35	16.0	29.2	X	X	X
40	18.8	X	X	X	X
45	25.2	X	X	X	X

- Depending on how viscous the oil was, the amplifier system reached its maximum power output before we could collect data for higher frequencies. Such data points are marked as “X” in the table.
- As our theory predicts, the critical acceleration threshold required for Faraday instability increases significantly at higher frequencies due to increased viscous dissipation.

Results



- Across all tested oils, the required voltage exhibited a characteristic non-linear dependence on the driving frequency.

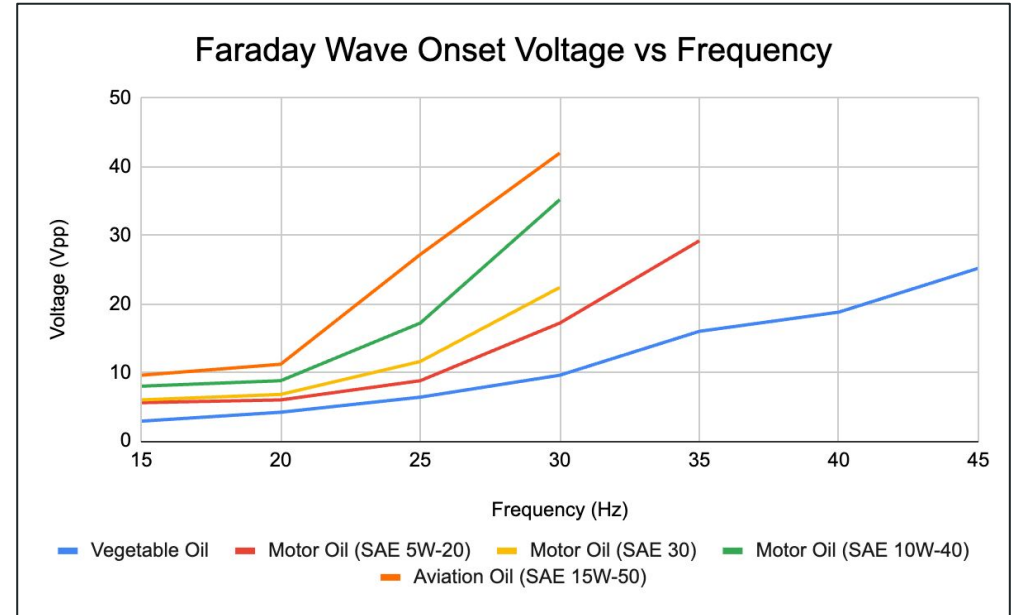
Conclusion

Across all five oils it was seen that the required voltage, and therefore the critical acceleration threshold, increased with driving frequency. It was observed at lower frequencies all five oils behaved similarly, but as frequency increased the more viscous oils need much larger voltages for Faraday waves to be observed.

From least to most viscous: vegetable oil, SAE 5W-20, SAE 30, SAE 10W-40, SAE 15W-50. [1,2]

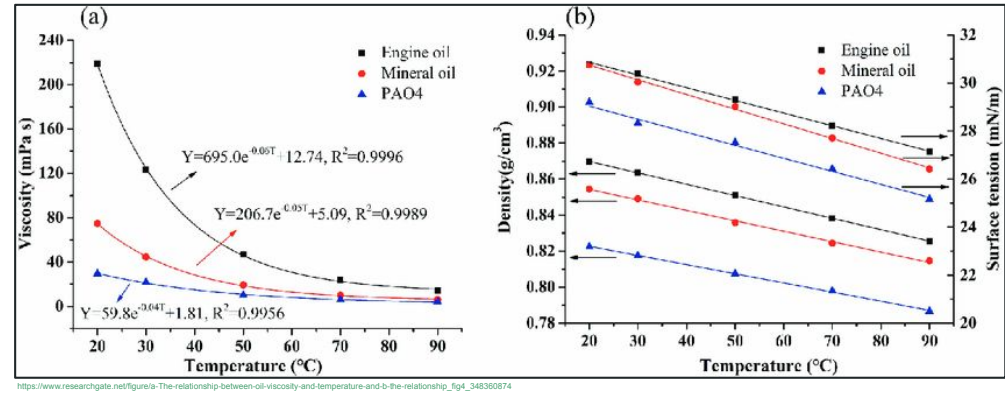
There is therefore a positive correlation between oil viscosity and the critical acceleration for Faraday wave formation.

Higher viscosity increases the critical acceleration threshold:



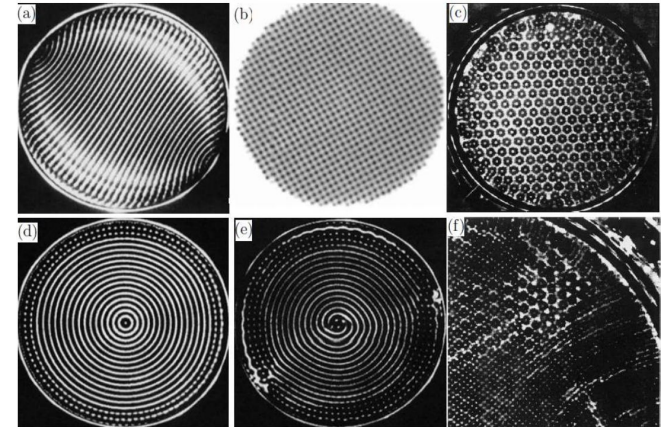
Errors

- Approximating the Faraday waves.
- Temperature and contamination of the oil.



Opportunities for Future Study

Change the amount of oil in the beaker and observe how both the viscosity of the oil and the amount play a role in determining the critical threshold.



<https://nslab.gatech.edu/images/9/95/ProjectFaraday2.pdf>

References

- [1] Castrol. (n.d.). *Oil viscosity chart & oil grades explained*. Castrol USA. Retrieved December 2, 2025, from https://www.castrol.com/en_us/united-states/home/learn/car-maintenance/oil-viscosity-explained.html Home
- [2] Ketheeswaren, S. (2004). *Viscosity of vegetable oil in the range of engine oil*. M.Sc. Thesis, Department of Physics, University of Jaffna. Retrieved from https://www.academia.edu/3807240/Viscosity_of_vegetable_oil_in_the_range_of_engine_oil