

SN: _____, Name: _____

ABSOLUTELY NO CHEATING!

Note: This is a close-book examine. You can use pencil or any pen in answering the problems. Dictionary and Calculators are NOT allowed.

Problems (5 Problems, total 100%)

- 1. Thermal energy, molar heat and first law (30%):** (a, 5%) A heating element is rated as "150W". What amount of energy will this heating element provide each minute? (b, 15%) A 150W heater is placed in 1 Kg of methanol and turned on for exactly 1 minute. The temperature increased by 3.54°C. Assuming that all the heat is absorbed by the methanol, calculate the molar heat capacity for liquid CH₃OH. (c, 10%) A 1/4hp (0.25 horse power) motor uses 187W of electric energy while delivering 35J of work each second. How much heat must be dissipated in the form of friction (heat)?
- 2. Simple harmonic Oscillation (20%):** A vertically suspended spring of negligible mass and force constant k is stretched by an amount l when a body of mass m is hung on it. The body is pulled by hand an additional distance y downward and then released. (a, 10%) Show that the motion of the body is governed by the equation $a = -ky/m$, so that the body executes harmonic motion about its equilibrium position, and (b, 10%) show that the period of this motion is the same as that of a simple pendulum of length l .
- 3. Simple Harmonic system (20%):** Refer to the figure to the right for a very simple mass-spring system. The attached mass is m , and the spring has a spring constant k . (a, 5%) Start from Newton's law, if you pull the mass with displacement x , and release it; it will start to oscillate. What is its acceleration a ? (b, 5%) Write down the differential equation that describes the oscillation. (c, 5%) Demonstrate, without solving it, that $x(t) = \cos(\omega t + \phi)$ is one of the possible solutions of the equation. (d, 5%) Solve the period of the oscillation.
- 4. Escape Speed (15%):** Estimate the size of a rocky sphere with a density of 3.0 g/cm³ from the surface of which you could just barely throw away a golf ball and have it never return. (Assume your best throw is 40 m/s).
- 5. Doppler effect (15%):** If a sound wave has a speed v and frequency f . What is the detected frequency when the source is moving at speed v_s towards the detector and the detector is stationary? Derive this.

