Quiz 5

Name: _____ Student Number: _____

CALCULATORS ALLOWED.

1. (2 marks) A windmill generates a power of 2 MW. Suppose it pumps water up to a reservoir 5 meters above ground. What is the maximum volume per second of water it can pump into the reservoir?

$$\text{Power} = \frac{\text{Mass}}{\text{sec}} \times g \times h$$

$$= \frac{\text{Volume}}{\text{sec}} \times \rho\, g h$$

$$\therefore \frac{\text{Volume}}{\text{sec}} = \frac{2 \times 10^6 \text{ Watt}}{10^3 \frac{\text{kg}}{\text{m}^3} \cdot 10 \frac{\text{m}}{\text{sec}} \cdot 5\text{m}}$$

$$= 40 \text{ m}^3/\text{sec}.$$

2. (2 marks) Compute the escape velocity of a 1000 kg spacecraft from the moon which has a radius 1740 km and a mass 7×10^{22} kg. The spacecraft has a length of 2.5 meters.

Pot. Energy at Moon surface $U = -\frac{G m M_M}{R_M}$

For escape moon we need total energy $= U + K.E. = 0$

$$\therefore -\frac{G m M_M}{R_M} + \frac{1}{2} m v^2 = 0.$$

$$v_{esc} = \sqrt{\frac{2GM_M}{R_M}}$$

$$= \left(\frac{2 \times 6.67 \times 10^{-11} \times 7 \times 10^{22}}{1.74 \times 10^6} \right)^{1/2}$$

$$= 2.3 \text{ km/sec}.$$

3. a) (2 marks) Estimate the maximum power generated by burning all of Toronto's garbage. (Assume 1 kg garbage generates about 5×10^6 Joules)

Each citizen generates ~ 1 kg garbage/week

$\therefore$ 2×10^6 citizens generate $\sim 2 \times 10^6$ kg.

$\Rightarrow = 10 \times 10^{12}$ J.

$$\therefore \text{Power} = \frac{10^{13}\ \text{J}}{7\ \text{days} \times 24\ \frac{\text{hr}}{\text{day}} \times 3600\ \frac{\text{sec}}{\text{hr}}}$$

$$= 16.5\ \text{MW}.$$

b) (1 mark) What fraction of Toronto's total electrical demand does this represent?

2 million people need about 4 GW.

$\therefore$ garbage power $\simeq 4 \times 10^{-3} << 1\%$.

4. A politician wishes to extend the shipping season thereby increasing the economic activity of a port.

a) (2 marks) How much power is needed to melt 0.5 km^3 of ice in one month? (Energy required to melt 1 gm ice = 79 calories/gram. 1 Calorie = 4.2 J) $\rho_{ice} = 0.92\ gm/cm^3$

$$\text{Energy Required} = 0.5\ km^3 \times \left(10^5 \frac{cm}{km}\right)^3 \times 0.92 \frac{gm}{cm^3} \times 79 \times 4.2 \frac{J}{gm}$$

$$= 1.5 \times 10^{17}\ J$$

$$\text{Power} = \frac{1.5 \times 10^{17}\ J}{30\ days \times 24 \frac{hr}{day} \times 3600 \frac{sec}{hr}}$$

$$= 5.9 \times 10^{10}\ \text{Watt}.$$

$$= 59\ GW$$

$\gg$ capacity of Ontario Hydro.

$\Rightarrow$ a truly silly idea.

b) (1 mark) Is this idea realistic?