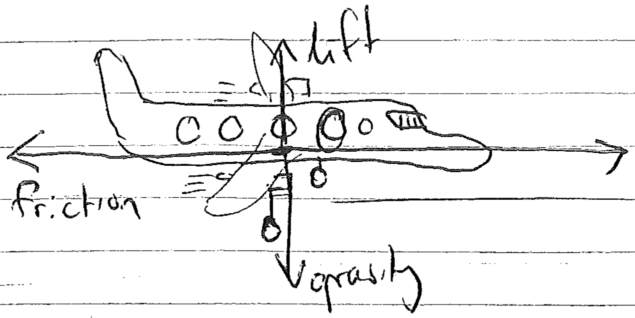
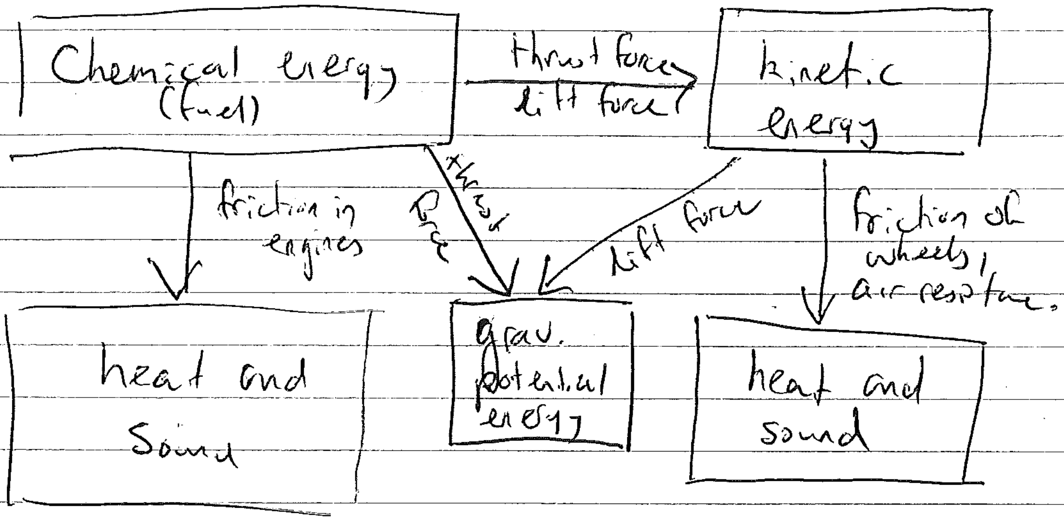
NCEA L2 Asst. 2 solutions.

1. Energy changes associated with an air line flight (incomplete list!)

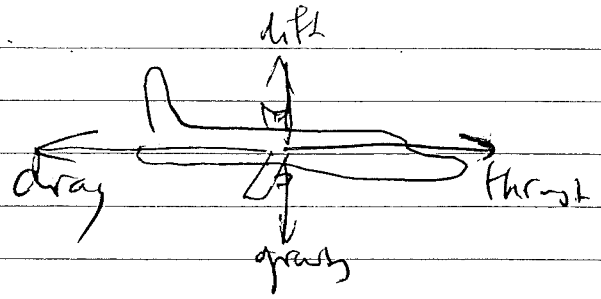
- Takeoff.



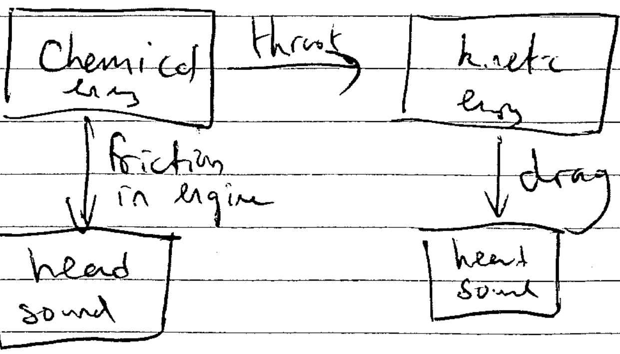
forces acting



- Flight.

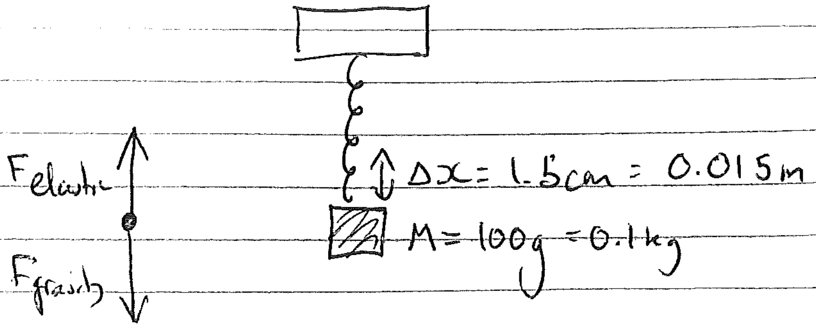


lift + gravity balanced, so no energy changes due to either.



etc.

2. a)

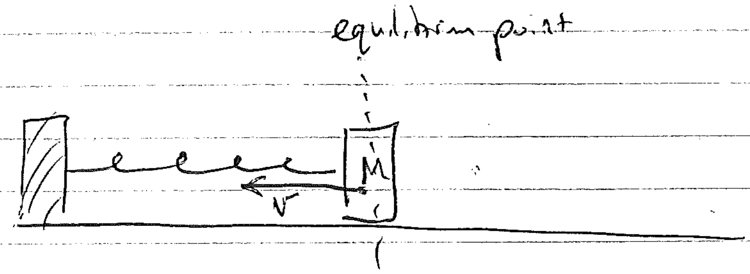


Both elastic & gravity forces act on the ~~spr.~~ mass, since the mass is not accelerating, they must balance (so are equal and opposite).

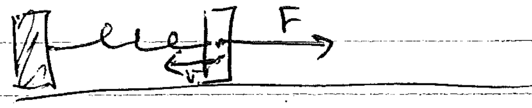
$$\text{elastic} = \text{gravity}$$

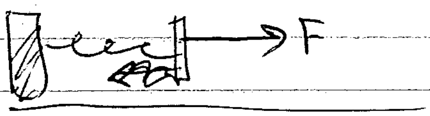
Hence
$$k\Delta x = Mg$$
$$k = \frac{Mg}{\Delta x} = \frac{0.1\,kg \times 9.81\,ms^{-2}}{0.015\,m} = 65.4\,kg\,s^{-2}.$$

b)



max. velocity when no force opposing (i.e. a=0)





no velocity at full compression.

and then reverse above until spring fully stretched.

By energy conservation, max. velocity attained when all the elastic energy is converted to kinetic energy. So

$$\frac{1}{2} k x_{max}^2 = \frac{1}{2} M v_{max}^2$$

$$\cancel{65.4\, x_{max}^2}$$

$$\therefore\ 65.4 \times 0.03 = 0.1 \times v_{max}^2$$

$$v_{max} = \sqrt{\frac{65.4 \times 0.03}{0.1}} = 4.43\,ms^{-1}.$$

3a. Gained energy $\frac{1}{2} \times 1350 \times 13.9^2$ $= 1.30 \times 10^5$ J.

Note: $50 kmh^{-1} = \frac{50 \times 1000}{60 \times 60} = 13.9 ms^{-1}$

All this energy comes from burning fuel; one litre of fuel contains 46.7×10^6 J/L, so volume used is

$$\frac{1.30 \times 10^5}{46.7 \times 10^6} = 0.0028 L = 2.8 \text{ millilitres.}$$

b. $W = F \times d$. Assuming friction acts directly opposed to the direction of motion,

$$\overbrace{\Delta E}^{5.3 \times 46.7 \times 10^6} = W = F \times \overbrace{d}^{100{,}000m} \quad F = \frac{5.3 \times 46.7 \times 10^6}{100{,}000} = \underline{2475 N.}$$

$\Delta E = \underline{2.475 \times 10^8 J}$

So if the engine cuts out, we have

$V_i = 13.9 ms^{-1}$

$V_f = 0 ms^{-1}$

$a = -F/m = -\frac{2475}{1350} = -1.83 ms^{-2}$

$$t = \frac{V_f - V_i}{a} = \frac{-13.9}{-1.83} = \underline{7.60 \text{ seconds}}.$$

4. a. $p_{initial} = 0.1kg \times 1ms^{-1} + 0.05kg \times 2ms^{-1}$
$= 0.2 kgms^{-1}$.

So $p_{final} = p_{initial} = 0.2 kgms^{-1}$ by cons. of mom.

And thus $v_{final} = \frac{p_{final}}{m} = \frac{0.2}{0.1+0.05} = 1.33 ms^{-1}$.

b. $K_{initial} = \frac{1}{2} \times 0.1 \times 1^2 + \frac{1}{2} \times 0.05 \times 2^2 = 0.15 J$.
$K_{final} = \frac{1}{2} \times (0.1 + 0.05) \times 1.33^2 = 0.1327 J$.

So $\Delta K = 0.017$ J lost.

c. It is not kinetic energy that is conserved, but total energy. We have not taken into account energy lost as heat or sound (this is where the missing 0.017J went).