Bobsleigh at 2006 Torino Games

1. If no friction or air resistance,

$$\Delta h = 1569\,m - 1683\,m = -114\,m$$

So change in GPE turns into KE

$$KE_i + GPE_i = KE_f + GPE_f$$

$$KE_f - KE_i = GPE_i - GPE_f$$

$$\tfrac{1}{2}mv_f^2 - 0 = mg|\Delta h|$$

$$\Rightarrow v_f = \sqrt{2g|\Delta h|} = \sqrt{2\left(9.8\tfrac{m}{s^2}\right)(114\,m)}$$

$$= 47.3\,\tfrac{m}{s}$$

2. Work done by gravity is

$$W_g = \int \vec{F}_g \cdot d\vec{x} = |F_g|\,|\text{vertical drop}|$$

$$= (630\,kg)\left(9.8\tfrac{m}{s^2}\right)(114\,m)$$

$$\cong 704 \times 10^3\,J$$

3. Under ideal conditions, it would be a tie. Both sleds would accelerate at same rate, and slide at same speed.

4. Under realistic conditions, the 4-man sleigh should win. Air resistance will exert a similar force on each, as will friction; but gravity will exert a larger force on the 4-man sleigh.

5. The curve marked "T" has a radius of curvature of

$$R \sim 50 \text{ m}.$$

Thus centripetal acceleration of sleigh will be

$$a = \frac{V^2}{R} = \frac{(36 \text{ m/s})^2}{50 \text{ m}} \approx 26 \frac{\text{m}}{\text{s}^2} \approx 2.6 \text{ gees}$$

6. If sleigh finishes at $V_f = 30$ m/s, then

$$KE_i + GPE_i = KE_f + GPE_f - W_f$$

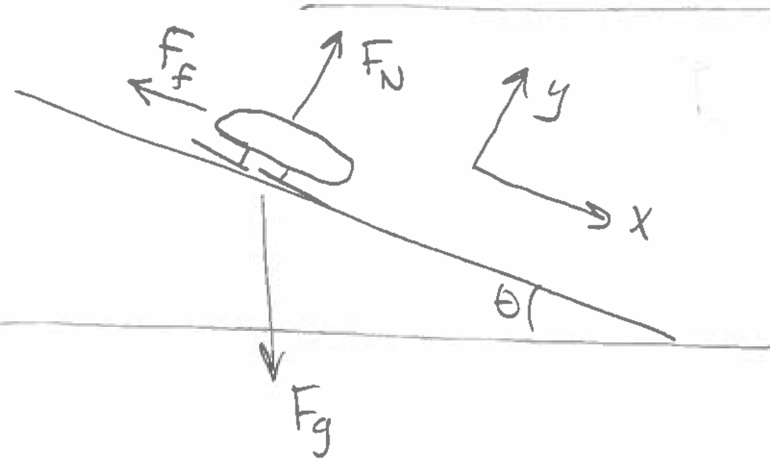
$$\Rightarrow W_f = (GPE_f - GPE_i) + (KE_f - KE_i)$$

$$\Rightarrow W_f = -mg|\Delta h| + \tfrac{1}{2}mv_f^2$$

$$= (-704 \times 10^3 \text{ J}) + (204 \times 10^3 \text{ J})$$

$$\boxed{W_f \cong -420 \times 10^3 \text{ J}}$$

7.



force	x	y
grav	$+mg\sin\theta$	$-mg\cos\theta$
Normal	0	$+F_N$
friction	$-\mu_k F_N$	0
	ma_x	$ma_y = 0$

We can figure out

$$F_N = mg\cos\theta$$

and so

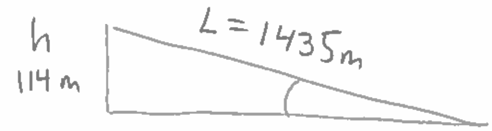
$$F_f = \mu mg\cos\theta$$

The work done by friction over the entire length $L = 1{,}435$ m is very roughly

$$W_f = \int \vec{F}_f \cdot d\vec{x} \cong -F_f L$$

$$\cong -\mu(mg\cos\theta)L$$

But we know from earlier



$$W_f \cong -420 \times 10^3 \text{ J}$$

$$\theta = \sin^{-1}\left(\frac{114 \text{ m}}{1435 \text{ m}}\right) = 4.56^\circ$$

$$\rightarrow \quad \mu \cong \frac{-420 \times 10^3 \text{ J}}{(630 \text{ kg})(9.8 \frac{\text{m}}{\text{s}^2})(\cos 4.56^\circ)(1435 \text{ m})}$$

$$\cong \underline{0.048}$$

---

8. Avg acceleration given by

$$(x - x_0) = \cancel{v_0 t} + \tfrac{1}{2}at^2$$

$$\rightarrow \quad a = \frac{2(x - x_0)}{t^2} = \frac{2(65 \text{ m})}{(5 \text{ s})^2} = 5.2 \text{ m/s}^2$$

Avg force

$$F = ma = (250 \text{ kg})(5.2 \text{ m/s}^2) = \underline{1300 \text{ N}}$$