Name: Solutions

Homework Week # 6

Centripetal Force & Energy
Due Thurs 10/03/19

Reading

C&J Physics: **Tues – Ch. 6: 1-5** **Thurs – Ch. 6: 6-9**

OS Coll Phys: **Tues – Ch. 7: 1-6** **Thurs – Ch. 7: 6-9**

FOC

Problems

Problem 1. **5.10**

Problem 2. **5.14**

Problem 3. **5.15**

Problem 4. **5.16**

Problem 5. **5.18**

Problem 6. **FOC 6.1**

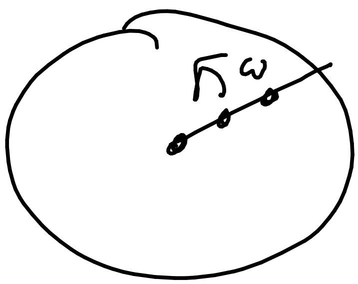
Problem 7. **6.1**

Problem 8. **6.2**

Prob. 1 5.10

If $a_c = 120 \frac{m}{s^2}$ @ $r = 0.030m$, what is a_c @ $r = 0.050m$

Note that for any object in UCM on the same circle ω const., but v, p not const.



$$a_c = r\omega^2$$

$$\omega^2 = \frac{a_c}{r}$$

$$\omega^2 = \frac{a_{c_1}}{r_1} = \frac{a_{c_2}}{r_2}$$ solve this for a_{c_2}

$$a_{c_2} = r_2 \frac{a_{c_1}}{r_1}$$

$$a_{c_2} = (0.050m) \frac{(120 \frac{m}{s^2})}{0.030 \frac{m}{s^2}} = (1.67)(120) \frac{m}{s^2}$$

$$\boxed{a_c = 200 \frac{m}{s^2} \text{ @ } r = 0.050m}$$

Prob 2 5.14

A person with a mass of 83.0 kg experiences a 560 N centripetal when moving at a speed of 3.2 $\frac{m}{s}$ on a spinning cylindrically shaped ride. What is the radius of the seat they sat in?

$F_c = 560\,N$, $v = 3.2\,\frac{m}{s}$, $m = 83.0\,kg$

Find r $\qquad F_c = m a_c \qquad a_c = \frac{v^2}{r}$

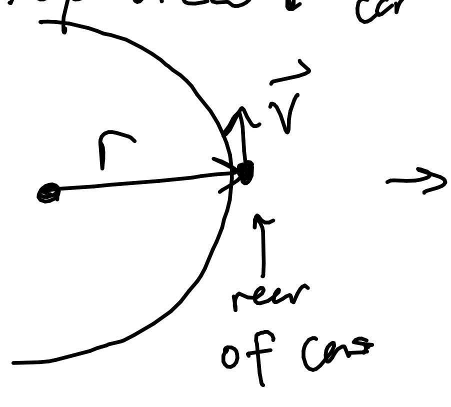
$$F_c = \frac{m v^2}{r} \xrightarrow[\text{for } r]{\text{solve}} r = \frac{m v^2}{F_c}$$

$$r = \frac{(83.0\,kg)(3.2\,\frac{m}{s})^2}{560\,N}$$

$$\boxed{r = 1.5\,m}$$

Prob. $3\frac{1}{2}$ 5.15

Two cars take a turn where static friction is the centripetal force on a level road. If there tires are different ($\mu_{s_a} = 1.1$, $\mu_{s_b} = 0.85$). If car A can travel the curve with a max speed of $v_A = 25\frac{m}{s}$, what is the max speed car B can?



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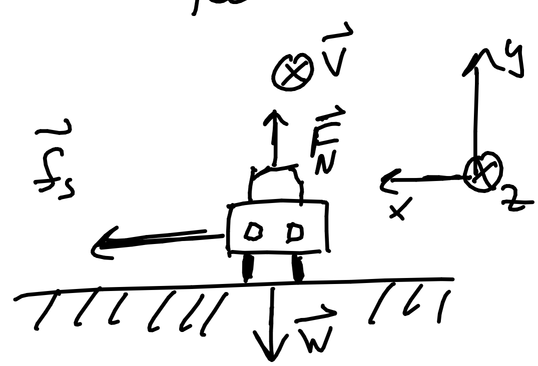
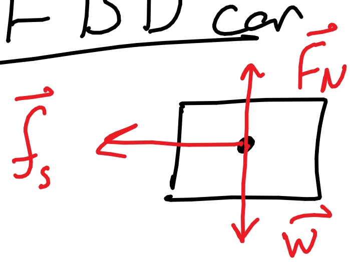


$\mu_B = 0.85$ $\qquad$ $\mu_A = 1.1$

$v_B = ?$ $\qquad$ $v_A = 25\frac{m}{s}$

FBD car



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$$\Sigma \vec{F} = m\vec{a}_c$$

$$F_x = f_s = ma_c$$

$$F_y = F_N - W = 0$$

Prob. 3 2/2

* if max speed, then car just about to slip (in x-dir) and lose control if speed is any faster: $f_s = \mu_s F_N$

from $\sum \vec{F} = m\vec{a}$:

$a_c = \frac{v^2}{r}$

$F_N = W = mg$

$f_s = m a_c = \mu_s (mg)$

$$\cancel{m}\frac{v^2}{r} = \mu_s \cancel{m} g$$

$$V_A^2 = r\mu_A g \quad \& \quad V_B^2 = r\mu_B$$

$$v^2 = r\mu_s g \rightarrow rg = \frac{v^2}{\mu_s}$$

* rg const. for both cars $\rightarrow \frac{V_A^2}{\mu_A} = \frac{V_B^2}{\mu_B}$ *

$$V_B^2 = \frac{\mu_B}{\mu_A} V_A^2 \rightarrow V_B = \sqrt{\frac{\mu_B}{\mu_A}}\, V_A$$

$$V_B = \sqrt{\frac{0.85}{1.1}}\left(25\,\frac{m}{s}\right) \boxed{\simeq 22\,\frac{m}{s}}$$

Prob. 4 5.16 5/11

Speed skater completes a turn with a radius of $r = 31\,m$. The skater experienced a 460 N when moving with a speed of $14.0\,\frac{m}{s}$. What is their mass?

$r = 31\,m$, $v = 14.0\,\frac{m}{s}$, $F_c = 460\,N$; $F_c = m a_c$, $a_c = \frac{v^2}{r}$

$$\therefore \quad m = \frac{F_c}{a_c} = \frac{F_c}{\left(\frac{v^2}{r}\right)} = \frac{F_c\, r}{v^2}$$

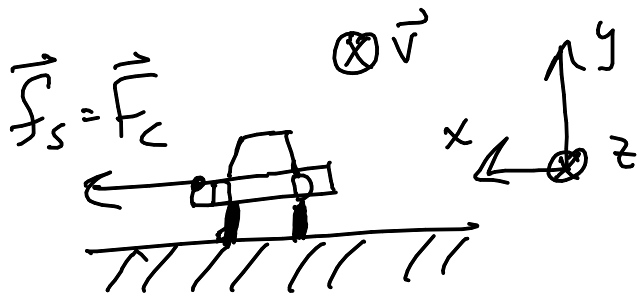
$$m = \frac{(460N)(31\,m)}{(14.0\,m/s)^2}$$

$$m = 73\ \frac{N \cdot s^2}{m} \quad ; \quad N = \frac{kg \cdot m}{s^2}$$

$$\boxed{m = 73\,kg}$$

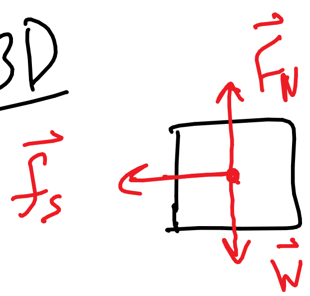
Prob. 5 1/2   5.18   6/11

Same premise to 5.15, but now one car that must slow down b/c μ_s changes/decreases when the road is wet compared to when dry.



$f_s = \mu_s N$ b/c just about to slip/start moving in x-dir.

FBD



$V_0 = 21\,\frac{m}{s}$; μ_0

$V_1 = ?$ when $\mu_1 = \frac{\mu_0}{3}$

$$\sum \vec{F} = m\vec{a}_c = \begin{cases} F_x = f_s = \mu F_N = \frac{mv^2}{r} \\ F_y = F_N - W = 0 \rightarrow F_N = W = mg \end{cases}$$

$$\mu m g = \frac{mv^2}{r} \rightarrow \frac{v^2}{r} = \mu g$$

Prob. 5 2/2 $\quad rg = \frac{v^2}{\mu}$

* same as before rg = const., but *
μ, v not const.

given
$\mu_1 = \frac{\mu_0}{3}$
$V_0 = 21\ m/s$

$$\frac{V_0^2}{\mu_0} = \frac{V_1^2}{\mu_1}$$

$$V_1^2 = \frac{\mu_1}{\mu_0} V_0^2 = \frac{\left(\frac{\mu_0}{3}\right)}{\mu_0} V_0^2$$

$$V_1^2 = \frac{1}{3} V_0^2$$

$$V_1 = \frac{1}{\sqrt{3}} V_0$$

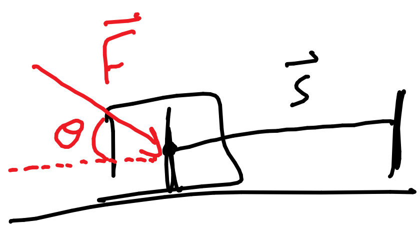
$$V_1 = \frac{1}{\sqrt{3}} (21\ m/s)$$

$$\boxed{V_1 = 12\ m/s}$$

Prob. 6 F.O.C. 6.1 8/11

W = Work = $Fs(\cos\theta)$. Rank the following by how much work done by the same force $\vec{F}$ on the box

A

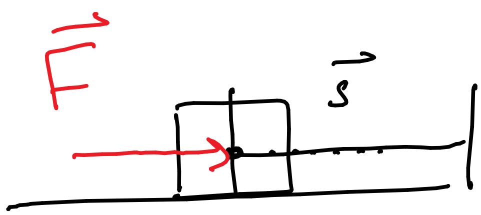


$0 < \theta < 90^\circ$

Force not efficiently used

$0 < \text{Work} < Fs$

B

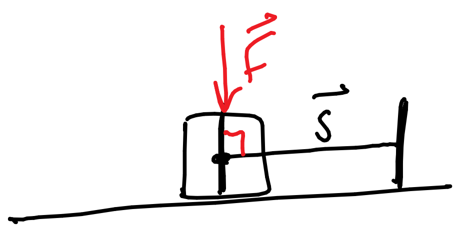


$\theta = 0^\circ$

Max Work

$W = Fs$

C



$\theta = 90^\circ$

No Work by F

$W = 0$

max work $\boxed{B, A, C}$ No work

Prob. 7 6.1 9/11

If an object is pulled parallel (completely aligned) with the displacement it experiences then that object has a maximum work done on it by the pulling force

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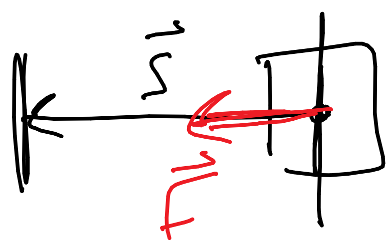
$F = 1100N$, $s = 2.0m$, $\theta = 0$



$W = Fs\cos\theta$

$$W = (1100N)(2.0m)\cancel{\cos 0}^{\,1}$$

$$= 2200\ N\cdot m$$

$$\boxed{W = 2200\ J}$$

$1J = 1\ N\cdot m$

$1J = 1$ joule

Prob. 8 $\frac{1}{2}$ 6.2

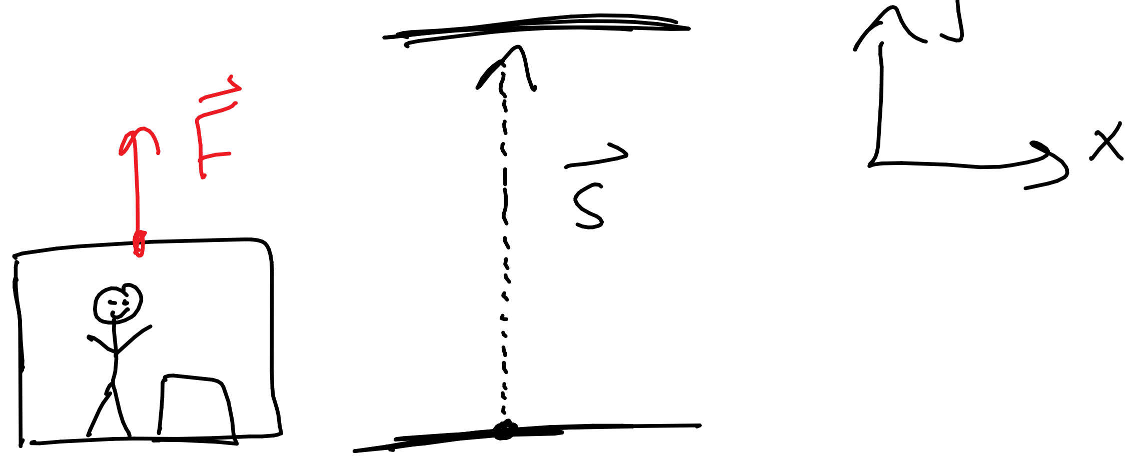
Determine the work done by an elevator when moving objects up and down.

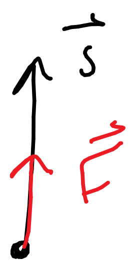
(a) up ; F_g = weight = 1600 N

(b) down; F_g = 685 N

both (a) & (b) $s = 15.2\,m$

(a)





$\theta = 0$

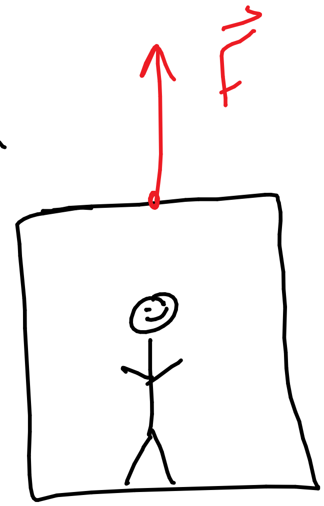
$F = F_g$

$$W = (1600N)(15.2m)\cos 0$$

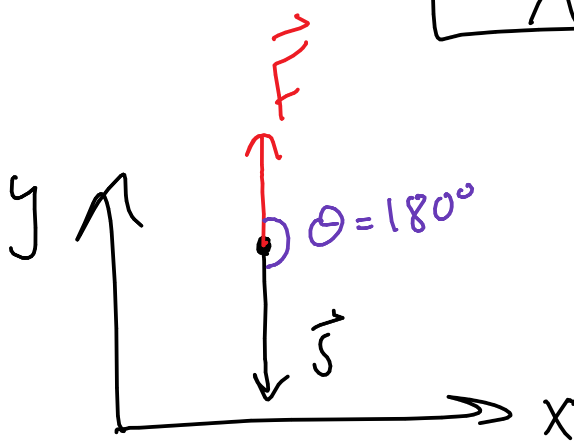
$$\boxed{\begin{aligned} W &= +24320\ J \\ W &= +24.3\ kJ \end{aligned}}$$

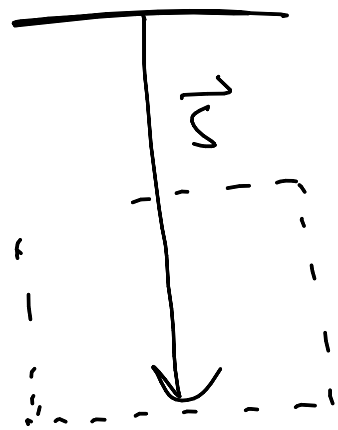
Prob. 8 2/2

(b)



$F = 685\,N$
$s = 15.2\,m$





$$W = Fs\cos\theta$$
$$= (685\,N)(15.2\,m)\cos 180°$$

$$\boxed{\begin{array}{l} W = -10412\,J \\ W = -10.4\,kJ \end{array}}$$