P113 S. Manly

University of Rochester Fall 2012

NAME SLM – Soln key

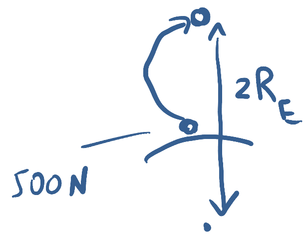
Exam 2 (October 25, 2012)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given unless specified otherwise.

Problem 1 (8 pts, give some indication of your thinking, i.e., show your work):

An astronaut who weighs 500 N on the surface of the earth is lifted to a height equal to the radius of the earth (above the surface of the earth, so her distance from the center is twice the radius of the earth). Her weight at the new height is

0 — a) Zero, she is weightless
0 — b) unchanged, i.e. 500 N
3 — c) (1/2)500 N = 250 N
8 d) (1/4) 500 N = 125 N
0 — e) (2)500 N = 1000 N
0 — f) (4)500 N = 2000 N

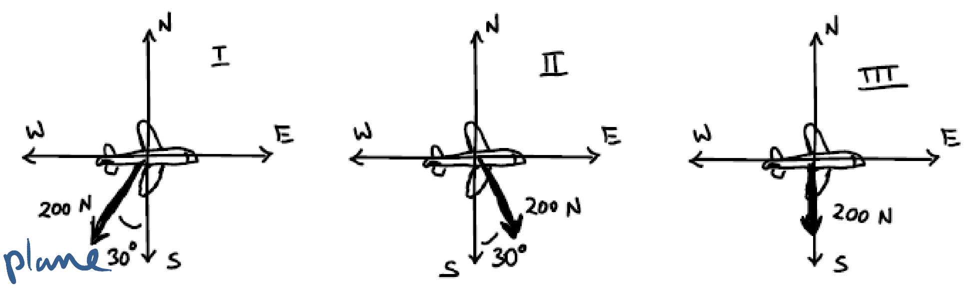


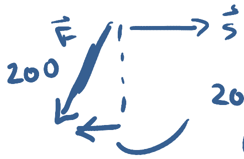
$500 = \frac{GM_E m}{R_E^2}$

New WT $= \frac{GM_E m}{(2R_E)^2} = \frac{500}{4} = 125\,N$

Problem 2 (15 pts, 5 pts per part, show work and/or give indication of your thinking):

(a) An airplane travels due east at 25 m/s. The plane encounters wind that exerts a force of 200N on the airplane in a direction of 30 degrees west of due south as shown in sketch (I) (which depicts the situation as seen from above). During the time that the airplane moves 3000 meters due east, how much work does the a~~irplane do against the force of the wind?~~ wind do on the airplane

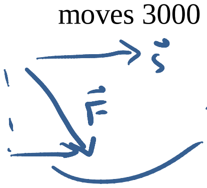




200 sin 30 (west)

$W = \vec{F} \cdot \vec{S} = -(200 \sin 30)(3000) =$
$-300{,}000\ J$

(b) If the 200 N force of the wind is exerted in the direction of 30 degrees east of south as shown in sketch (II), how much work does the ai~~rplane do against the force of the wind~~ wind do on the airplane as the plane moves 3000 meters east?

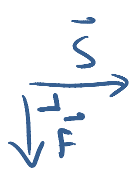


200 sin 30 (east)

$W = \vec{F} \cdot \vec{S} = (200 \sin 30)(3000) = 300{,}000\ J$

(c) Finally, if the 200 N force exerted by the wind on the plane is in the southerly direction (as shown in sketch III), how much work does the ai~~rplane do against the force of the wind~~ wind do on the airplane as the plane moves 3000 meters east?

$W = \vec{F} \cdot \vec{S} = 0$



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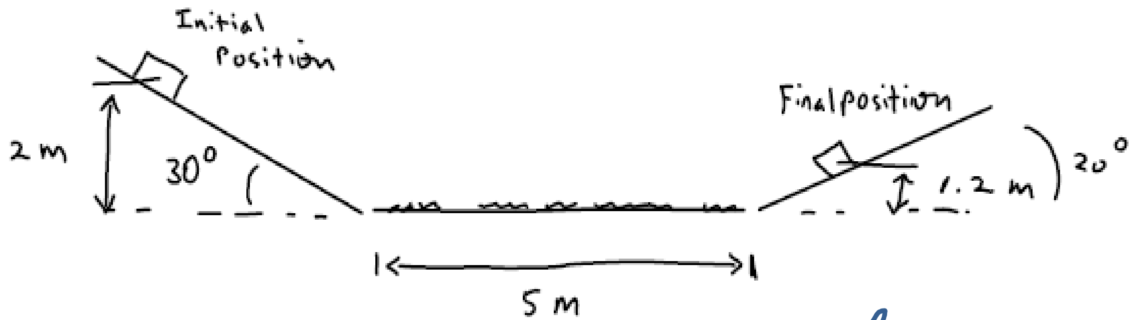
Problem 3 (12 pts, show work):

A 4 kg block slides down a frictionless inclined plane from a height of 2 meters. The plane makes an angle of 30 degrees with the horizontal. Once at the bottom of the inclined plane, the block slides 3 meters along floor before sliding up to a height of 1.2 meters on another frictionless inclined plane which makes an angle of 20 degrees with the horizontal axis. What is the coefficient of kinetic friction that characterizes the frictional force between the block and the floor?



$$E_i = W_{Fr} + E_f$$

$$mgh_i = W_{Fr} + mgh_f$$

$$mg(h_i - h_f) = W_{Fr}$$

$$(4)(9.8)(0.8) = \mu_k N(5)$$

$N = (4)(9.8)$

$$\mu_k = \frac{0.8}{5}$$

$$\mu_k = 0.16$$

The Angles are irrelevant here. just tossed in to make it more fun :)

1)	8 /8
2)	15 /15
3)	12 /12
4)	15 /15
5)	25 /25
6)	25 /25
tot	100 /100

:) Woohoo!!

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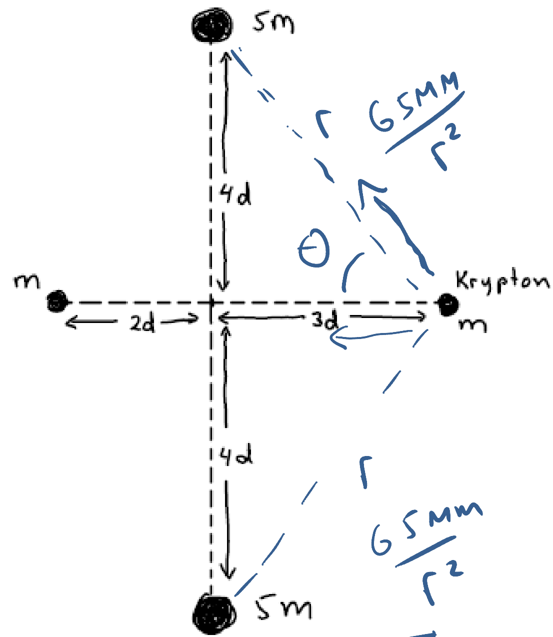
Problem 4 (15 pts total, show your work):

Consider the planet Krypton of mass, m, which is near three other planets as shown in the sketch.



(a) (10 pts) Determine the magnitude and direction of the net gravitational force on Krypton. Specify the direction and give the magnitude of this force in terms of the gravitational constant and the variables m and d.

$+x \leftarrow$

$$\vec{F} = \hat{x}\left[\underbrace{(2)\frac{G5mm}{25d^2}\frac{3}{5}}_{\text{From the 2 (5M) Masses}} + \frac{Gmm}{25d^2}\right]$$

$\frac{3}{5} = \cos\theta$

$$r = \sqrt{(3d)^2+(4d)^2} = 5d$$

$$F\cos\theta = F\frac{3}{5}$$

$$\boxed{\vec{F} = \hat{x}\,\frac{7}{25}\frac{Gm^2}{d^2}}$$

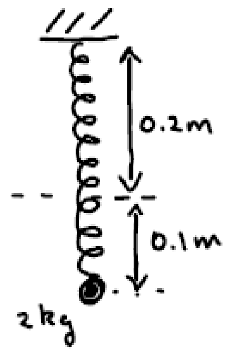
(To the left)

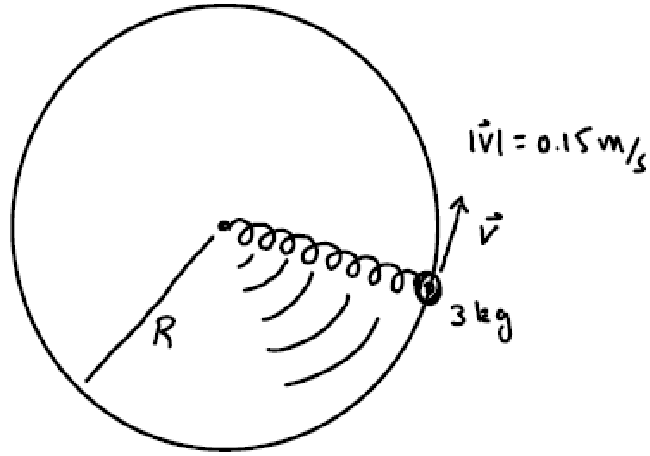
(b) (5 pts) Ignoring any contribution from planet Krypton itself, what is the gravitational field at the location of planet Krypton?

$$\boxed{\vec{g} = \frac{\vec{F}}{m} = \hat{x}\,\frac{7}{25}\frac{Gm}{d^2}}$$

Problem 5 (25 pts total, show your work):

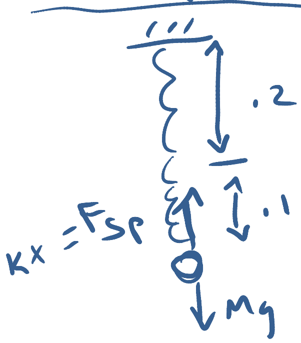
Jethro Snodworth has a problem. He likes to play with springs. I mean he REALLY likes to play with springs. It wouldn't really stretch the imagination to think of him as a springaholic, constantly bouncing in and out of spring rehab. Anyway, one day you run into Jethro playing with a spring and you are inspired to do some calculations while watching him. Go you!





Jethro has a spring has a natural length of 0.2 m. When a block of mass 2 kg is gently hung from this spring (so that it hangs without moving) by Jethro, it stretches the spring by a length of 0.1 meter. Afterwards, Jethro attaches a block of 3 kg to the spring and rotates the block in a horizontal circle on a frictionless surface (as shown in the sketch, viewed from above). Once the block and spring combination are stably rotating, you measure the speed of the block to be 1 m/s. Determine the radius of the circle, R, along which the block is moving as shown in the sketch. *(Note, the plane of this circle is horizontal and you are viewing it from above. You do not want to be considering gravity for the circular part of this problem!)*

First step — calculate k



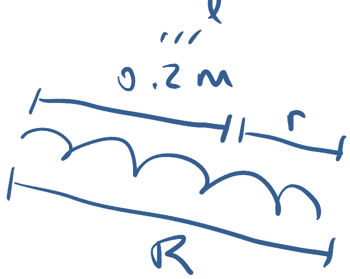
$Kx = mg$

$k = \frac{mg}{x}$

$k = \frac{(2)(9.8)}{.1} = 196\ N/m$

2ND step - use Circular Motion Force sum

$\Sigma F = mv^2/R$



R = nat. length of spring + stretch = $l + r$

$kr = \frac{mv^2}{R}$

$kr = \frac{mv^2}{l+r}$

$klr + kr^2 - mv^2 = 0$

$r^2 + lr - \frac{mv^2}{k} = 0$

0.2 3 1^2 196

quadratic in r

$r = \frac{-.2 \pm \sqrt{.2^2 + \frac{(4)(3)}{196}}}{2}$

$r = 0.32$

$R = 0.2 + 0.32$

$R = 0.52\ m$

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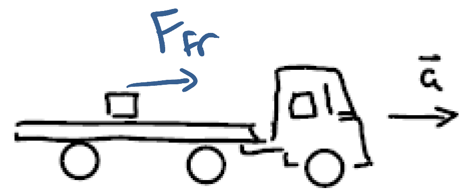
Problem 6 (25 pts total, show your work):

(a) (6 pts) Consider a mass m=0.1kg that sits on a flat surface on the back of a truck. The coefficient of static friction characterizing the friction between the block and the surface of the truck bed is 3. If the truck accelerates at 4 m/s^2 and the mass does not slide on the bed of the truck, is the direction of the force of friction along the direction of the acceleration of the truck or in the opposite direction? Indicate the direction of the frictional force on the mass in the sketch. No need to show work for this part.



Has to be to the right ... F_{Fr} is the force that accelerates the mass

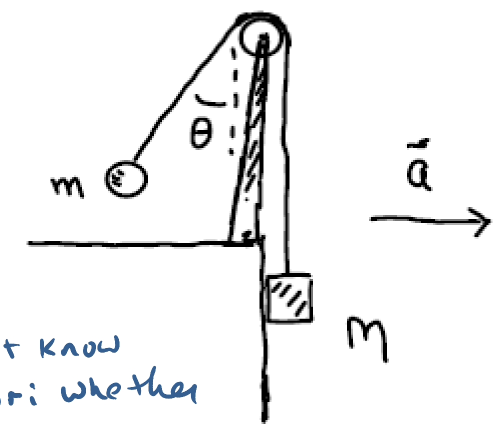
(b) (6 pts) What is the force of friction between the truck bed and the block when the truck accelerates at 4 m/s^2 and the block does not slip?

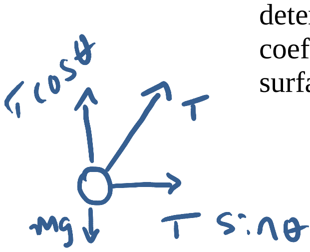
$F_{Fr} = ma = (0.1)(4) = 0.4\ N$

only needs to be 0.4 N to satisfy Newton's laws

note $F_{Fr} < F_{Fr\,Max} = \mu_s N = (3)(.1)(4) = 1.2\ N$

(c) (13 pts) Consider the physical situation portrayed in the sketch. A block of mass M=1 kg is in contact with the vertical surface of the front of a truck. A string attaches the block to a ball of mass m=0.5 kg in the configuration shown in the sketch. If the truck accelerates at 4 m/s^2, determine the tension in the string and the minimum value of the coefficient of static friction between the mass M and the surface of the front of the truck such that M does not slide along surface.





$ma = T\sin\theta$

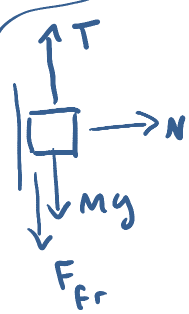
$mg = T\cos\theta$

$\tan\theta = \frac{a}{g} = \frac{4}{9.8}$

$\theta = 22.2^\circ$

$T = \frac{ma}{\sin\theta} = \frac{(0.5)(4)}{\sin(22.2)}$

$T = 5.3\ N$



Do not know apriori whether F_{Fr} is up or down

$N = Ma = (1)(4) = 4$ Newtons

$F_{Fr} = N\mu_s = Mg - T$

$\mu_s = \frac{Mg - T}{N} = \frac{9.8 - 5.3}{4} = \frac{4.5}{4}$

$\mu_s \simeq 1.13$

$$\sin\theta = \frac{\text{opp}}{\text{hyp}}$$

$$\cos\theta = \frac{\text{adj}}{\text{hyp}}$$

$$\tan\theta = \frac{\text{opp}}{\text{adj}}$$

$$v = v_o + at$$

$$x = x_o + v_o t + \frac{1}{2}at^2$$

$$x = x_o + \left(\frac{v_o + v}{2}\right)t$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

$$x - x_o = \int_{t_o}^{t} v\,dt$$

$$v - v_o = \int_{t_o}^{t} a\,dt$$

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

$$F_{friction} = \mu_k N$$

$$F_{friction} \le \mu_s N$$

$$F_{centripetal} = \frac{mv^2}{r}$$

$$\vec{F}_{spring} = -k(\vec{x} - \vec{x}_o)$$

$$work = \int F \cdot ds$$

$$power = \frac{dw}{dt}$$

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_x B_x + A_y B_y + A_z B_z$$

$$\vec{F} = -\frac{Gm_1 m_2 \hat{r}}{r^2}$$

$$G = 6.67\text{x}10^{-11}\ \text{Nm}^2/\text{kg}^2$$

$$PE_{grav} = -\frac{GM}{r}$$

$$PE_{spring} = \frac{1}{2}kx^2$$

$$\text{circumference of circle} = 2\pi r$$

$$\text{area of circle} = \pi r^2$$

$$\text{quadratic equation} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\frac{d(x^n)}{dx} = nx^{n-1}$$

$$\int x^n dx = \frac{x^{n+1}}{n+1}$$