EXAM 2, PH111
3/8/13, Dr. Strong

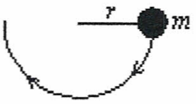
NAME KEY

Please PRINT your name as it appears on my class roster.

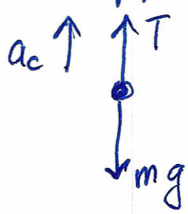
Circle one answer for each problem; do not leave any problems blank.

Turn in exam and all scratch paper used during exam.

BONUS QUESTION (5 Points): A small object of mass *m*, on the end of a light cord, is held horizontally at a distance *r* meters from a fixed support as shown. The object is then released with an initial velocity such that $K_i = U_i / 2$. **In terms of *mg*,** what is the tension in the cord when the object is at the lowest point of its swing?



1st, know @ bottom that T must support mg and a_c accounts for the acceleration @ bottom



So: $ma_c = T - mg$

$\therefore T = ma_c + mg = F_c + mg$

2nd $\Delta K + \Delta U = 0$

$K_f - K_i + \cancel{U_f}^{0} - U_i = 0$ but $K_i = U_i/2 = mgr/2$

$\frac{1}{2}mv_f^2 - mgr/2 - mgr = 0$

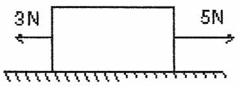
$\frac{1}{2}mv_f^2 = mgr/2 + mgr = \frac{3}{2}mgr$

Cancel $\frac{1}{2}$'s, ÷ by r $\frac{mv_f^2}{r} = 3mg$, but F_c @ bottom $= 3mg$

Finally $T = F_c + mg = 3mg + mg = \boxed{4mg}$

Sp '13 KEY

1. The block shown moves with a very small acceleration to the left on a horizontal surface. Two of the forces acting on the block are shown. A frictional force exerted by the surface is the only other horizontal force acting on the block. The frictional force must be:

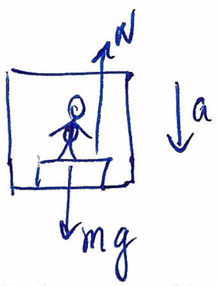


A) 0
B) 2 N, rightward
3 C) 2 N, leftward
D) slightly more than 2 N, leftward
E) slightly less than 2 N, rightward

want left force to be larger than right force

2. A man weighing 700 N is standing on a scale in an elevator that is falling and its speed is increasing at 3.2 m/s^2. The reading on the scale is:

A) 2200 N
sign 4 B) 930 N
C) 700 N
D) 470 N
<700 2 E) 230 N

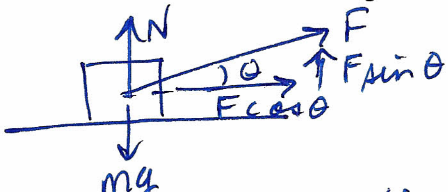


$\Sigma F = ma = mg - N$

$N = mg - ma = 700N - \left(\frac{700N}{9.8 m/s^2}\right)(3.2 m/s^2)$

$= 471 N$

3. A 25-kg chair is pulled across a frictionless horizontal floor with a force of 50 N, directed 30° above the horizontal. The magnitude of the normal force of the floor on the chair is:



A) 0 N
Fsinθ 2 B) 25 N
C) 50 N
D) 220 N
sign 4 E) 270 N

$\Sigma F_y = 0 = N + F\sin\theta - mg$

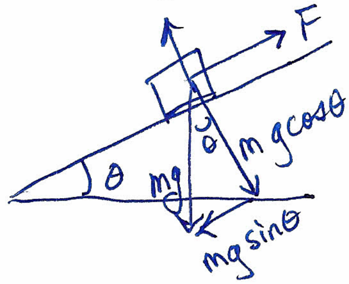
$N = mg - F\sin\theta$

$N = (25kg)(9.8 m/s^2) - 50N\sin 30°$

$= 220N$

4. A force, $\boldsymbol{F}$, parallel to the incline, is required to push a certain crate at constant velocity up a frictionless incline that is an angle of $\boldsymbol{\theta}$ above the horizontal. The mass of the crate is given by:

A) $F/g\sin\theta$
sin 3 B) $F/g\cos\theta$
C) g
D) F
÷g 3 E) $Fg/\sin\theta$



$F = mg\sin\theta$

$\therefore m = F/g\sin\theta$

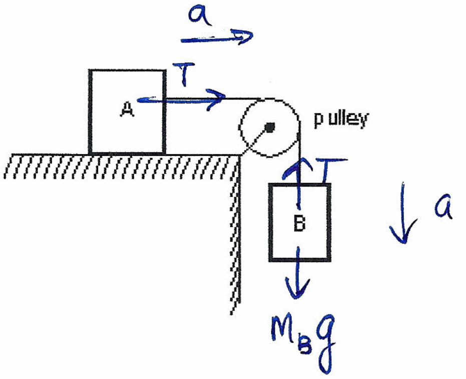
5. Block A, with weight 65 N, and block B with weight 30 N are connected by a string as shown. If the pulley is massless and the horizontal surface is frictionless, find the magnitude of the acceleration of the system once the blocks are released. (*Hint: The blocks accelerate together; you must write equations for the sum of forces for each block to solve this.*)

$\Sigma F_A = M_A a = T$

$\Sigma F_B = M_B a = M_B g - T$

solve for T to eliminate

$T = M_A a = M_B g - M_B a$



A) 1.5 m/s^2
B) 3.1 m/s^2
C) 4.9 m/s^2
$\Sigma M_A)$ 4 D) 6.7 m/s^2
$\frac{}{M_A - M_B}$ 2 E) 11.8 m/s^2

then

$(M_A + M_B) a = M_B g$

$$a = \frac{M_B g}{M_A + M_B} = \frac{(30\,N)}{(65+30)/9.8\,m/s^2} = 3.09\,m/s^2$$

6. A 35-N force, parallel to the incline, is required to push a certain crate at constant velocity up a frictionless incline that is 35° above the horizontal. The mass of the crate is:

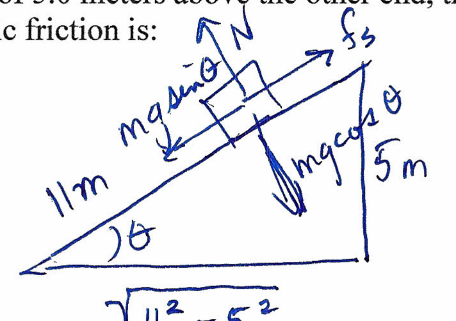
A) 6.2 kg
cos θ 3 B) 4.3 kg
C) 10 kg
D) 35 kg
1/9.8 3 E) 61 kg

Same as #4

$$m = F/g\sin\theta = 35\,N/(9.8\,m/s^2)(\sin 35°)$$

$$= 6.23\,kg$$

7. A box rests on a rough board 11 meters long. When one end of the board is slowly raised to a height of 5.0 meters above the other end, the box just begins to slide. The coefficient of static friction is:



cos 3 A) 0.89
B) 0.55
C) 0.51
sin 3 D) 0.45
E) 0.11

$f_s = mg\sin\theta = \Sigma F_{\parallel}$

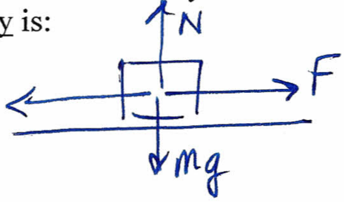
but $f_s = \mu_s \cancel{N} = \mu_s mg\cos\theta$

So $\mu_s mg\cos\theta = mg\sin\theta$

and $\mu_s = \tan\theta$

$$\therefore \mu_s = \frac{5\,m}{\sqrt{11^2 - 5^2}} = 0.51$$

8. Camping equipment weighing 4500 N is pulled across a frozen lake by means of a horizontal rope. The coefficient of kinetic friction is 0.04. The work done by the campers in pulling the equipment 1400 m <u>at constant velocity</u> is:



A) 0.25 MJ
B) 3.0×10^6 J
C) 2.5×10^6 J (0.4) 4
D) 5.0 MJ
E) 2.5×10^5 J

BONUS +2

$F = f_k$ for no acceleration

$f_k = \mu_k N = \mu_k mg$

and $W = F \cdot d = \mu_k mg\, d$

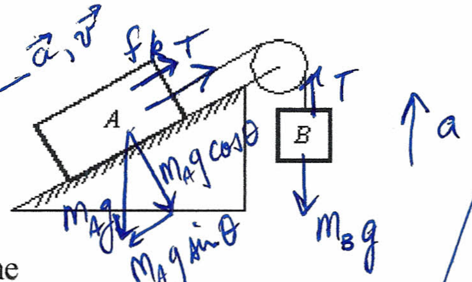
$= (0.04)(4500N)(1400\,m) = 252000\,J$

9. Block A, with a mass of 10 kg, is initially <u>moving down</u> a 30° incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 8.0 kg, is attached to the dangling end of the string. The acceleration of A is: assume $\vec{a}$ downd incline

$\Sigma F_{\parallel} = M_A a = M_A g \sin\theta - T - f_k$

$\Sigma F_y = M_B a = T - M_B g$

eliminate T



But $f_k = \mu_k M_A g\cos\theta$

then

$$a = \frac{\left(M_A g\sin\theta - \mu_k M_A g\cos\theta - M_B g\right)}{M_A + M_B}$$

$$a = \frac{\left(10(9.8)\sin 30° - 0.2(10)(9.8)\cos 30° - 8(9.8)\right)}{10+8}$$

$a = -2.6\ m/s^2$

sign 3 A) 0.69 m/s², up the incline
sign/dir. 2 B) 0.69 m/s², down the incline
C) 2.6 m/s², up the incline
direction 4 D) 2.6 m/s², down the incline
E) 0

$T = M_B a + M_B g = M_A g\sin\theta - f_k - M_A a$

then $M_B a + M_A a = M_A g \sin\theta - f_k - M_B g$

10. A stone of mass *m* is attached to a string and swung in a circle of radius *r* on a horizontal and frictionless surface. The time for the stone to make one revolution is *t*. Find the tension force in the string. (*Hints: Tension must be the centripetal force.)*

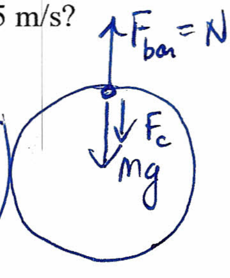
( )² 4 A) $2\pi mr / t$
B) $4\pi^2 mr / t^2$
(2πr) 2 C) mv / t
(2πr) 2 D) mr / t^2
E) mg

1 rev = $2\pi r$

and $v = \frac{2\pi r}{t}$

$$T = F_c = \frac{mv^2}{r} = \frac{m\left(\frac{2\pi r}{t}\right)^2}{r} = \frac{4\pi^2 mr}{t^2}$$

11. Each car on a carnival Ferris Wheel ride hangs on a bar of negligible mass. Each car + riders weighs a total of 5000 N and the radius of the Wheel's circle is 10m. How much support force must the bar supply at the top of the circle if the speed is 5 m/s?



mv^2/r 2 A) 1300 N
sign 4 B) 3700 N
C) 5000 N
D) 6300 N
(9.8) 3 E) 18 kN

$N = mg + F_c = mg + mv^2/r$

$= 5000N + \left(\frac{5000N}{9.8\,m/s^2}\right)\left(\frac{(5\,m/s)^2}{10m}\right)$

$= 6276\,N$

12. A 4.0-kg cart starts up an incline with a speed of 3.0 m/s and is still moving at 2.0 m/s at a higher point on the incline. The magnitude of the work done on the cart is:

v_i^2 only 3 A) 18 J
B) 12 J
C) 10 J
v_f^2 only 3 D) 8 J
E) 2 J

$W = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(v_f^2 - v_i^2)$
$= \frac{1}{2}(4kg)(2^2 - 3^2) = -10J$

13. A large bedspring of spring constant 45 N/cm is secured to the floor. A mass is placed on top of the spring compressing it 2.0 cm. How much work does the spring do during this compression?

conv. 2 A) 90 J
sign 4 B) 0.9 J
C) 45 J
D) –0.9 J
conv. 4 E) -9×10^{-3} J

$W_s = -\frac{1}{2}k(x_f^2 - x_i^2)$
$= -\frac{1}{2}\left(45\frac{N}{cm}\right)\left(\frac{100cm}{1m}\right)\left((0.02m)^2 - 0\right)$
$= -0.9J$

14. A 2.0-kg particle on the end of an ideal spring is pulled out 0.50 m from the equilibrium position and released from rest. The spring constant is 200 N/m. When the particle passes the point where the spring force is zero, its speed is

A) 0
B) 5 m/s
$\sqrt{\frac{k}{m}x}$ 3 C) 7.1 m/s
$\sqrt{}$ 4 D) 25 m/s
E) 100 m/s

$\Delta K + \Delta U = 0$
$K_f - \cancel{K_i} + \cancel{U_f} - U_i = 0$
$\frac{1}{2}mv_f^2 = \frac{1}{2}kx_i^2$
$v_f = \sqrt{\frac{k}{m}}\,x_i = \sqrt{\frac{200 N/m}{2kg}}(0.5m) = 5 m/s$

15. When a certain rubber band is stretched a distance x, it exerts a restoring force $F = ax + bx^2$, where a and b are constants. The work done in stretching this rubber band from $x = 0$ to $x = L$ is:

S error 3 A) $aL^2 + bL^3$
B) $aL + bL^2$
deriv. 2 C) $a + 2bL$
D) bL
E) $aL^2/2 + bL^3/3$

$W = \int F\,dx = \int_0^L (ax + bx^2)\,dx = \left(\frac{ax^2}{2} + \frac{bx^3}{3}\right)\Big|_0^L$
$= \frac{aL^2}{2} + \frac{bL^3}{3}$

16. A freight elevator is used to move 12 refrigerators, 145 kg each, upwards 16 meters in 1.5 minutes. The power required is:

A) 6.8 kW
B) 3.0 kW
(9.8) 3 C) 310 W
(12) 3 D) 250 W
(16) 3 E) 180 W

$P = \frac{W}{t} = \frac{F \cdot d}{t} = \frac{mgd}{t} = \frac{(145kg)(9.8 m/s^2)(16m)}{(1.5min)\left(\frac{60s}{1min}\right)} \times 12$

$= 3031 W = 3 kW$

17. A simple pendulum consists of a bowling ball attached to a 12-m rope. The speed of the bowling ball as it passes through its lowest point is 5.5 m/s. To what maximum angle will the ball swing?

A) 30°
(B) 29°
3 C) 42°
3 D) 60°
3 E) 84°

$\frac{1}{2}\frac{v_i^2}{gL}$ ×2 (1 −)

$\Delta K + \Delta U = 0$

$\cancel{K_f} - K_i + U_f - \cancel{U_i} = 0$

$\frac{1}{2}mv_i^2 = mgh = mg(L - L\cos\theta)$

$\frac{\cancel{m}v_i^2}{2\cancel{m}gL} = 1 - \cos\theta$

$\cos\theta = 1 - \frac{v_i^2}{2gL}$

$\theta = \cos^{-1}\left(1 - \frac{v_i^2}{2gL}\right)$

$\theta = \cos^{-1}\left(1 - \frac{(5.5)^2}{2(9.8)(12)}\right)$

$= 29°$

18. A 0.50-kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. The total mechanical energy is 0.56 J. When the potential energy is 0.14 J, what is the speed of the block is?

A) 0.50 m/s
only 0.14 3 B) 0.75 m/s
(C) 1.30 m/s
> 1.3 3 D) 1.44 m/s
only 0.56 3 E) 1.5 m/s

$E = K + U$

$K = E - U$

$\frac{1}{2}mv^2 = E - U$

$v = \sqrt{\frac{2(E-U)}{m}}$

$v = \sqrt{\frac{2(0.56 - 0.14)}{0.5}}$

$= 1.296 \text{ m/s}$

19. You push a 2.0 kg block against a horizontal spring with k = 200 N/m, compressing the spring a distance of 15 cm. You release the block, allowing it to slide across the tabletop, encountering friction only **<u>once it leaves the spring</u>**. The block stops 60 cm from the relaxed position of the spring. What is the coefficient of kinetic friction?

<1 2 A) 0.10
(B) 0.19
both ( )² 3 C) 0.32
(½) 3 D) 0.64
E) 1.3

$\Delta K + \Delta U = -f_k d$

$\cancel{K_f} - \cancel{K_i} + \cancel{U_f} - U_i = -f_k d$

$\frac{1}{2}kx^2 = \mu_k mgd$

$\mu_k = \frac{\frac{1}{2}kx^2}{mgd}$

$= \frac{\frac{1}{2}(200\text{ N/m})(0.15)^2}{(2)(9.8)(0.6\text{ m})} = 0.19$

20. In an experiment at MSFC, a 25-g ball is released from rest 90 m above the surface of the Earth. Just before it hits the surface its speed is 30 m/s. What is the change in energy of the ball during its fall?

no cal'n A) 0 J
sign 4 B) 11 J
(C) −11 J
D) −25 J
E) 245 J

$\Delta K + \Delta U = \Delta E$

$K_f - \cancel{K_i} + \cancel{U_f} - U_i = \Delta E$

$\frac{1}{2}mv_f^2 - mgh = \Delta E$

$\Delta E = \frac{1}{2}(0.025\text{ kg})(30)^2 - (0.025)(9.8)(90\text{ m})$

$= -10.8\text{ J}$

SCORING:

20 *Questions* ________

Bonus points ________

Total ________

ANSWER KEY – SPRING 2013, EXAM 2

Problem	Answer	4pts	3pts	2pts
1.	D		C	
2.	D	B		E
3.	D	E		B
4.	A		B, E	
5.	B	D		E
6.	A		B, E	
7.	C		A, D	
8.	A, E BONUS +2	C		
9.	C	D	A	B
10.	B	A		C, D
11.	D	B	E	A
12.	C		A, D	
13.	D	B, E		A
14.	B	D	C	
15.	E		A	C
16.	B		C, D, E	
17.	B		C, D, E	
18.	C		B, D, E	
19.	B		C, D	A
20.	C	B		A
	5	4	3	2

+5 POINT BONUS FOR CORRECT DERIVATION

82

44

37