Solutions

Fall 2013 RED barcode here
Physics 105, sections 1, 2 and 3
Exam 3
Colton

Please write your CID_____

No time limit. No notes. No books. Student calculators only. All problems equal weight, 100 points total.

Constants/Materials parameters:

$g = 9.8$ m/s^2
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2
$k_B = 1.381 \times 10^{-23}$ J/K
$N_A = 6.022 \times 10^{23}$
$R = k_B \cdot N_A = 8.314$ J/mol·K
$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4
Mass of Sun = 1.991×10^{30} kg
Mass of Earth = 5.98×10^{24} kg

Radius of Earth = 6.38×10^6 m
Radius of Earth's orbit = 1.496×10^{11} m
Density of water: 1000 kg/m^3
Density of air: 1.29 kg/m^3
Linear exp. coeff. of copper: 17×10^{-6} /°C
Linear exp. coeff. of steel: 11×10^{-6} /°C
Specific heat of water: 4186 J/kg·°C
Specific heat of ice: 2090 J/kg·°C

Specific heat of steam: 2010 J/kg·°C
Specific heat of alum.: 900 J/kg·°C
Latent heat of melting (water): 3.33×10^5 J/kg
Latent heat of boiling (water): 2.26×10^6 J/kg
Thermal conduct. of alum.: 238 J/s·m·°C
$v_{sound} = 343$ m/s at 20°C

Conversion factors

1 kg = 2.205 lb
1 inch = 2.54 cm
1 mile = 1.609 km
1 m^3 = 1000 L

1 hp = 745.7 W
1 gallon = 3.785 L
1 atm = 1.013×10^5 Pa = 14.7 psi

$T_F = \frac{9}{5}T_C + 32$
$T_K = T_C + 273.15$

Other equations

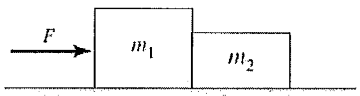
$x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
Surface area of sphere = $4\pi r^2$
Volume of sphere = $(4/3)\pi r^3$
$v_{ave} = \dfrac{v_i + v_f}{2}$
$v = v_0 + at$
$x = x_0 + v_0 t + \frac{1}{2}at^2$
$v_f^2 = v_0^2 + 2a\Delta x$
$w = mg$, $PE_g = mgy$
$F = -kx$, $PE_s = ½ kx^2$
$f = \mu_k N$ (or $f \le \mu_s N$)
$P = F_{//}v = Fv\cos\theta$
$\vec{F}\Delta t = \Delta\vec{p}$
Elastic: $(v_1 - v_2)_{bef} = (v_2 - v_1)_{after}$
arc length: $s = r\theta$
$v = r\omega$
$a_{tan} = r\alpha$
$a_c = v^2/r$
$F_g = \dfrac{GMm}{r^2}$, $PE_g = -\dfrac{GMm}{r}$
$I_{pt\,mass} = mR^2$
$I_{sphere} = (2/5)\,mR^2$
$I_{hoop} = mR^2$

$I_{disk} = (1/2)\,mR^2$
I_{rod} *(center)* $= (1/12)\,mL^2$
I_{rod} *(end)* $= (1/3)\,mL^2$
$L = r_\perp p = rp_\perp = rp\sin\theta$
$P = P_0 + \rho gh$
$VFR = A_1v_1 = A_2v_2$
$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$
$\Delta L = \alpha L_0 \Delta T$
$\Delta V = \beta V_0 \Delta T$; $\beta = 3\alpha$
transl. $KE_{ave} = \frac{1}{2}mv_{ave}^2 = \frac{3}{2}k_BT$
$Q = mc\Delta T$; $Q = mL$
$\dfrac{\Delta Q}{\Delta t} = kA\dfrac{T_2 - T_1}{L}$
$P = e\sigma AT^4$
$|W_{on\,gas}|$ = area under P-V curve
$= |P\Delta V|$ (constant pressure)
$= |nRT\ln(V_2/V_1)|$ (isothermal)
$= |\Delta U|$ (adiabatic)
$U = \frac{3}{2}Nk_BT = \frac{3}{2}nRT$ (monatomic)

$U = \frac{5}{2}Nk_BT = \frac{5}{2}nRT$ (diatomic, around 300K)
$Q_h = |W_{net}| + Q_c$
$e = \dfrac{|W_{net}|}{Q_{added}} = 1 - \dfrac{Q_c}{Q_h}$
$e_{max} = 1 - \dfrac{T_c}{T_h}$
$\omega = \sqrt{\dfrac{k}{m}}$, $T = 2\pi\sqrt{\dfrac{m}{k}}$
$\omega = \sqrt{\dfrac{g}{L}}$, $T = 2\pi\sqrt{\dfrac{L}{g}}$
$v = \sqrt{\dfrac{T}{\mu}}$, $\mu = m/L$
$\beta = 10\log\left(\dfrac{I}{I_0}\right)$ $I_0 = 10^{-12}$ W/m^2
$f' = f\dfrac{v \pm v_0}{v \pm v_S}$
$\sin\theta = v/v_s$
o-o/c-c: $f_n = nf_1$; $n = 1,2,3,\ldots$
o-c: $f_n = nf_1$; $n = 1,3,5,\ldots$

Instructions:

- Write your CID at the top of the first page, otherwise you will not get this exam booklet back.
- Circle your answers in this booklet if you wish, but be sure to **record your answers on the bubble sheet.**
- Unless otherwise specified, **ignore air resistance** in all problems.
- Use g = 9.8 m/s^2.



1. Two blocks (m_1 = 3 kg, m_2 = 2 kg) sitting on a frictionless table are pushed from the left by a horizontal force as shown, with F = 10 N. They accelerate to the right. Which number is closest to the magnitude of the force *between* the two blocks?

   a. 1 N
   b. 2
   c. 3
   d. 4
   e. 5
   f. 6
   g. 7
   h. 8
   i. 9
   j. 10 N

   $\Sigma F_{group} = m_{group} a_{group}$

   $F = (m_1 + m_2)\, a$

   $a = F/(m_1+m_2)$

   Then $\Sigma F_{m_2} = m_2 a$

   $F_{between} = m_2 \left(\frac{F}{m_1+m_2}\right) = 10 \cdot \frac{2}{5} = \boxed{4\text{ N}}$

2. Suppose you are an astronaut in interstellar space and a fellow astronaut throws a 1.5 kg wrench at you with a speed of 5 m/s. You try to grab the wrench, but can't grab onto the wrench and only manage to apply a stopping force of 10 N over a distance of 0.3 m. What is the final velocity of the wrench? (It doesn't change its direction.)

   a. Less than 3.4 m/s
   b. 3.4 – 3.6
   c. 3.6 – 3.8
   d. 3.8 – 4.0
   e. 4.0 – 4.2
   f. 4.2 – 4.4
   g. 4.4 – 4.6
   h. More than 4.6 m/s

   $E_{bef} + W = E_{aft}$

   $\frac{1}{2} m v_0^2 - Fd = \frac{1}{2} m v_f^2$

   $v_f = \sqrt{v_0^2 - \frac{2Fd}{m}} = \sqrt{5^2 - \frac{2(10)(.3)}{1.5}} = \boxed{4.58 \frac{m}{s}}$

3. When is momentum conserved?

   a. Always
   b. If there are no external forces
   c. If there are no internal forces
   d. If there are no conservative forces
   e. If there are no non-conservative forces
   f. Never

4. On an air track with no friction, a moving cart of mass *m* and velocity of 1 m/s to the right collides with a stationary cart of mass 5*m*. The moving cart bounces backwards at half of its original speed. Which number is closest to the speed with which the larger cart moves off to the right?

   a. 0.1 m/s
   b. 0.2
   c. 0.3
   d. 0.4
   e. 0.5
   f. 0.6
   g. 0.7
   h. 0.8
   i. 0.9
   j. 1 m/s

   Before: m → 1 m/s; 5m 0

   After: ← m .5 m/s; 5m → v_f = ?

   $\Sigma P_{bef} = \Sigma P_{aft}$

   $\cancel{m}(1) = -\cancel{m}(.5) + (5\cancel{m})\, v_f$

   $1.5 = 5 v_f$

   $v_f = \frac{1.5}{5} = \boxed{.3\ m/s}$

5. Same situation. Was kinetic energy conserved?

   a. Yes
   b. No

   $KE_{before} = \frac{1}{2}(m)(1^2)$

   $KE_{after} = \frac{1}{2}(m)(.5^2) + \frac{1}{2}(5m)(.3^2)$

   $= \frac{1}{2} m\, (.25 + .45)$

   $= \frac{1}{2} m\, (.7)$

   $= 70\%$ of KE_{before}

6. A 6000 kg truck collides head-on with a 2000 kg car. Both are initially traveling at a speed of 22 m/s (49.2 mph, the truck to the right and the car to the left. The collision lasts 0.3 seconds and causes the two to stick together and continue along to the right. Ignore friction. What was the average acceleration (magnitude) of the truck during the collision?
   a. Less than 35 m/s^2
   b. 35 – 36
   c. 36 – 37
   d. 37 – 38
   e. 38 – 39
   f. 39 – 40
   g. 40 – 41
   h. More than 41 m/s^2

Before: 6000 kg → 22 m/s ← 2000 kg 22 m/s || After: 8000 kg → v_f

First, find v_f:

$\Sigma P_{bef} = \Sigma P_{aft}$

$(6000)(22) - (2000)(22) = (8000)v_f$

$v_f = 11$ m/s

Then, use def of acceleration: $a_{ave} = \frac{\Delta v}{\Delta t} = \frac{11-22}{.3} = \boxed{-36.67 \frac{m}{s^2}}$

magnitude = 36.67

7. Herman (70 kg) is standing on a wooden platform (140 kg), which is on an ice-skating rink. There is friction between Herman and the platform, but no friction between the platform and the ice. Everything is motionless until Herman starts walking to the right at 1 m/s (relative to the ground). What happens to the platform? (All speeds are measured relative to the ground.)
   a. It remains motionless.
   b. It starts moving to the left at 0.5 m/s.
   c. It starts moving to the left at 1 m/s.
   d. It starts moving to the left at some other speed.
   e. It starts moving to the right at 0.5 m/s.
   f. It starts moving to the right at 1 m/s.
   g. It starts moving to the right at some other speed.

before after

v_f ← to the left!

$\Sigma P_{bef} = \Sigma P_{aft}$

$0 = (70)(1) - 140\, v_f$

$v_f = .5$ m/s to the left

8. Same situation. Herman stops walking after one meter. What is the state of the platform after he stops?
   a. It is motionless.
   b. It is moving to the left.
   c. It is moving to the right.

Total p is still 0.

9. Hardison (80 kg) slides across frictionless ice, moving at 2 m/s to the east. He throws his boots (2 kg) such that they end up going (relative to the ground) due north at 10 m/s. What angle is his body (now 78 kg) traveling at now, measured as a deflection from his original eastward direction? Call the angle a positive number regardless of whether it's a northward or southward deflection.
   a. Less than 4.0°
   b. 4.0 – 4.5
   c. 4.5 – 5.0
   d. 5.0 – 5.5
   e. 5.5 – 6.0
   f. 6.0 – 6.5
   g. 6.5 – 7.0
   h. More than 7.0°

Before: 80 kg → 2 m/s After: 10 m/s, 2 kg boots; θ, v, 78 kg

$\Sigma P_{bef\,x} = \Sigma P_{aft\,x}$

$(80)(2) = (78)(v\cos\theta)$

$160 = 78\, v\cos\theta$

$\Sigma P_{bef\,y} = \Sigma P_{aft\,y}$

$0 = (2)(10) - (78)(v\sin\theta)$

$20 = 78\, v\sin\theta$

$160 = 78\, v\cos\theta$

divide: $20/160 = \tan\theta \Rightarrow \boxed{\theta = 7.125°}$

10. A bullet imbeds itself into a block of wood tied to a string; the block of wood then swings up to a certain angle as in the "ballistic pendulum" example discussed in class. Which is true about the final potential energy of the block/bullet combo, $PE_{combined}$, relative to the initial kinetic energy of the bullet, KE_{bullet}?
   a. $PE_{combined} < KE_{bullet}$
   b. $PE_{combined} = KE_{bullet}$
   c. $PE_{combined} > KE_{bullet}$

energy is lost in the collision as the bullet embeds itself into the block

11. A large super-ball (mass $2m$) and a small super-ball (mass m) collide head-on with the same speed, v. The larger ball was traveling to the right, the smaller one to the left. The collision is elastic. What speeds do the two balls have after the collision? Positive means "to the right" and negative means "to the left". Hint for making the equations easier: If you assume that the initial velocity is 1 m/s, then if you get an answer of (for example) 0.5 m/s that would really be "1/2 v".

a. Large: –1/2 v; Small: +2 v
b. Large: –1/3 v; Small: +5/3 v
c. Large: –1/4 v; Small: +3/2 v
d. Large: –1/5 v; Small: +7/5 v
e. Large: –1/6 v; Small: +4/3 v
f. Large: 0 v; Small: +v
g. Large: +1/6 v; Small: +2/3 v
h. Large: +1/5 v; Small: +3/5 v
i. Large: +1/4 v; Small: +1/2 v

$2m$ v → ← v m | $2m$ → V_1 m → V_2

guess to the right

Eqn 1

$\Sigma P_{bef} = \Sigma P_{aft}$

$2\cancel{m}v - \cancel{m}v = 2\cancel{m}v_1 + \cancel{m}v_2$

$2v_1 + v_2 = v$

Eqn 2 = velocity reversal

$(v_1 - v_2)_{before} = (v_2 - v_1)_{after}$

$v - (-v) = v_2 - v_1$

$v_2 - v_1 = 2v$

Solve simultaneously

$v_2 = (v_1 + 2v)$

$2v_1 + (v_1 + 2v) = v$

$3v_1 = -v$

$\boxed{v_1 = -\frac{1}{3}v}$

plug back in

$v_2 = -\frac{1}{3}v + 2v$

$\boxed{v_2 = \frac{5}{3}v}$

12. A firework initially at rest in outer space explodes into 10 pieces. The largest piece, equal to half the total mass, flies off to the right at speed v. Which of the following is true about the position of the center of mass of the group of pieces after the explosion?

a. It remains in the same spot the firework was before the explosion.
b. It travels off to the right at a speed between 0 and ½ v.
c. It travels off to the right at a speed of ½ v.
d. It travels off to the right at a speed between ½ v and v.
e. It travels off to the right at a speed of v.
f. It travels off to the right at a speed of more than v.
g. It travels off in an unknown direction, specified by the behavior of the other nine pieces.

No outside force, so C.O.M. stays in constant motion as per Newton's 1st Law. In this case, that means it stays at rest.

13. A merry-go-round at first has a constant angular velocity, making a revolution every three seconds. Then Jill starts slowing it down at a rate of –1 rad/s². How many revolutions does it take to stop?

$\omega = \frac{1\text{ rev}}{3\text{ sec}} \times \frac{2\pi\text{ radians}}{1\text{ rev}} = \frac{2}{3}\pi\ \frac{\text{rad}}{\text{s}}$

a. Less than 0.1 revs
b. 0.1 – 0.2
c. 0.2 – 0.3
d. 0.3 – 0.4
e. 0.4 – 0.5
f. 0.5 – 0.6
g. 0.6 – 0.7
h. 0.7 – 0.8
i. 0.8 – 0.9
j. More than 0.9 revs

$v_f^2 = v_0^2 + 2a\Delta x$

Angular form:

$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

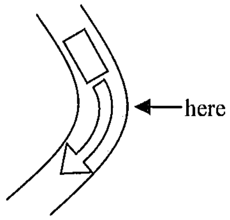
$0 = \left(\frac{2\pi}{3}\right)^2 + 2(-1)\Delta\theta$

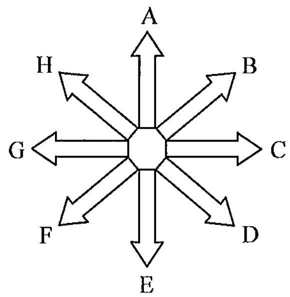
$\Delta\theta = 2.193\text{ radians} \times \frac{1\text{ rev}}{2\pi\text{ rad}} = \boxed{0.349\text{ revolutions}}$

14. Amy sits in a spinning chair, holding two weights out to the side. Then she pulls the weights in, causing her rotation to speed up. Which answer most correctly describes the situation?

a. Kinetic energy has decreased because she has a reduced moment of inertia.
b. Kinetic energy has been conserved because the decreased moment of inertia is balanced by her additional rotational speed.
c. Kinetic energy has increased because of the work involved in pulling in the weights.

Angular mom. is conserved, but not kinetic energy.





15. A car goes around a corner as shown, at constant speed. At the point labeled "here", what general direction is the car's acceleration?

centripetal (inward) acceleration only

   a. A
   b. B
   c. C
   d. D
   e. E
   f. F
   g. G
   h. H
   i. None; the car is not accelerating.

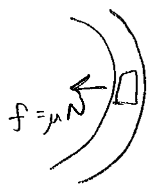
16. Same situation, except now the car is speeding up as it rounds the corner. What direction is the acceleration? Same answer choices.

tangential acceleration = southward

$\leftarrow$ accel. + $\downarrow$ tang. = $\swarrow$ a total

choice F

17. A 1500 kg car enters a flat highway via an unbanked turn of radius 20 m. The coefficient of static friction between the road and tires is 0.85. What is the maximum speed the car can have on this curve without starting to slide off the road?
   a. Less than 10.5 m/s
   b. 10.5 – 11.0
   c. 11.0 – 11.5
   d. 11.5 – 12.0
   e. 12.0 – 12.5
   f. 12.5 – 13.0
   g. 13.0 – 13.5
   h. 13.5 – 14.0
   i. More than 14.5 m/s



$\Sigma F_y = 0 \rightarrow N = mg$

$\Sigma F_x = ma_c$

$\mu N = \frac{mv^2}{r}$

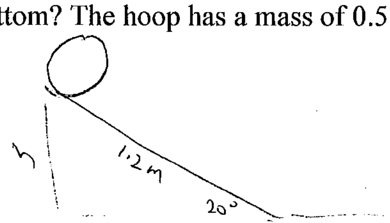
$\mu(\cancel{m}g) = \frac{\cancel{m}v^2}{r}$

$v = \sqrt{\mu r g} = \sqrt{(.85)(20m)(9.8\frac{m}{s^2})}$

$= \boxed{12.91\ m/s}$

$I = mr^2$

18. A hoop rolls without slipping down a ramp that is 1.2 m long, with an angle of 20° from horizontal. How fast will the hoop be going at the bottom? The hoop has a mass of 0.5 kg and a radius of 15 cm.
   a. Less than 1.9 m/s
   b. 1.9 – 2.1
   c. 2.1 – 2.3
   d. 2.3 – 2.5
   e. 2.5 – 2.7
   f. 2.7 – 2.9
   g. 2.9 – 3.1
   h. More than 3.1 m/s



$h = 1.2\sin 20°$

$E_{bef} + W = E_{aft}$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}(mr^2)\left(\frac{v}{r}\right)^2$

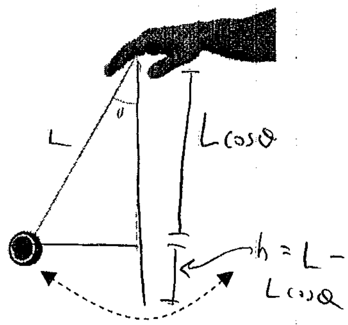
$\cancel{m}g(1.2\sin 20°) = \frac{1}{2}\cancel{m}v^2 + \frac{1}{2}\cancel{m}v^2$

$g(1.2\sin 20°) = v^2$

$v = \sqrt{(9.8\frac{m}{s^2})(1.2m)\sin 20°}$

$\boxed{v = 2.006\ m/s}$

19. Barney swings a 150 g yo-yo back and forth with a maximum angle of $\theta = 30°$ as in the picture. The string length of 40 cm does not change. What is the speed of the yo-yo at the lowest point? Note: Be careful, since the next problem depends on this answer.



a. Less than 1.00 m/s
b. 1.00 – 1.05
c. 1.05 – 1.10
d. 1.10 – 1.15
e. 1.15 – 1.20
f. 1.20 – 1.25
g. 1.25 – 1.30
h. More than 1.30 m/s

$E_{bef} + \cancel{W} = E_{aft}$

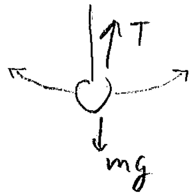
$mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh}$

$= \sqrt{2(9.8)(.4 - .4\cos 30°)}$

$= \boxed{1.0249\ m/s}$

20. Same situation. What is the tension in the string at the lowest point?



a. Less than 1.5 N
b. 1.5 – 1.6
c. 1.6 – 1.7
d. 1.7 – 1.8
e. 1.8 – 1.9
f. 1.9 – 2.0
g. 2.0 – 2.1
h. 2.1 – 2.2
i. 2.2 – 2.3
j. More than 2.3 N

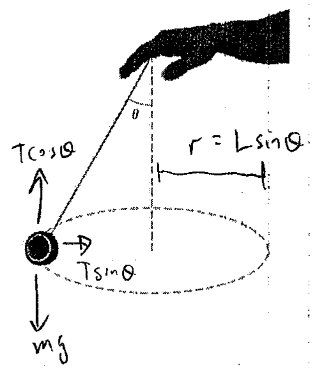
$\Sigma F = ma_c$

$T - mg = \frac{mv^2}{r}$

$T = \frac{mv^2}{r} + mg$

$T = \frac{(.15)(1.0249)^2}{.4} + (.15)(9.8) = \boxed{1.864N}$

21. Similar situation. Now, instead of just swinging it back and forth, Barney swings it in a circle, as shown. The angle θ in the picture is again 30°. The yo-yo's speed, however, is now NOT quite what you found in the previous problem. What *is* its speed as it goes around the circle?



a. Less than 1.00 m/s
b. 1.00 – 1.05
c. 1.05 – 1.10
d. 1.10 – 1.15
e. 1.15 – 1.20
f. 1.20 – 1.25
g. 1.25 – 1.30
h. More than 1.30 m/s

$\Sigma F_y = 0$

$T\cos\theta = mg$ → Combine by dividing

$\Sigma F_x = ma_c$

$\frac{T\sin\theta = \frac{mv^2}{r}}{T\cos\theta = mg}$

$\tan\theta = \frac{v^2}{rg}$

$v = \sqrt{rg\tan\theta} = \sqrt{(.4\sin 30°)(9.8)(\tan 30°)} = \boxed{1.0638\ \frac{m}{s}}$

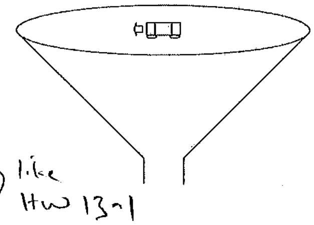
22. Same situation. What is the tension in the string as it goes around the circle?

a. Less than 1.5 N
b. 1.5 – 1.6
c. 1.6 – 1.7
d. 1.7 – 1.8
e. 1.8 – 1.9
f. 1.9 – 2.0
g. 2.0 – 2.1
h. 2.1 – 2.2
i. 2.2 – 2.3
j. More than 2.3 N

Can use y-equation

$T = \frac{mg}{\cos\theta} = \frac{(.15)(9.8)}{\cos 30°} = \boxed{1.697\ N}$

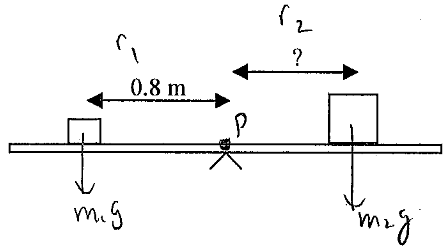
23. A car goes around a giant funnel as in the figure. The funnel is frictionless, but because the car has just the right velocity it doesn't slide down. To analyze such a problem (e.g. to solve for the needed speed based on the angle) how best should you draw your axes?



a. In the normal x and y-directions.
b. In the "tilted" x and y-directions.

Because a_x = centripetal = v^2/r and $a_y = 0$ } like HW 13-1

24. A 5 kg block is positioned on a see-saw, 0.8 m to the left of the middle. How far to the right of the middle must a 15 kg block be positioned to balance? All distances are measured to the center of the mass of the blocks.



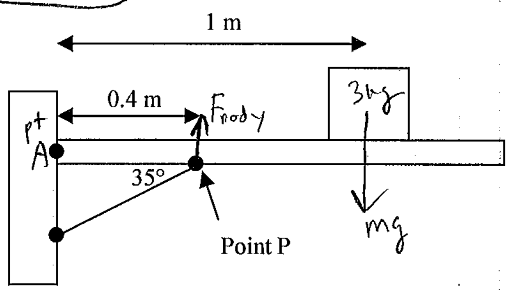
a. Less than 0.10 m
b. 0.10 – 0.15
c. 0.15 – 0.20
d. 0.20 – 0.25
e. 0.25 – 0.30
f. 0.30 – 0.35
g. 0.35 – 0.40
h. More than 0.40 m

$\sum \tau_p = 0 \rightarrow m_1 \cancel{g} r_1 = m_2 \cancel{g} r_2$

$r_2 = r_1\left(\frac{m_1}{m_2}\right)$

$= .8m\left(\frac{5}{15}\right) = \boxed{.2667\,m}$

25. A 3 kg box is placed on a very light board (essentially no mass), 1 m from where the board is connected to the wall. The board is also supported by a thin rod, connected at point P. The rod is attached at a 35° angle as shown, and point P is located 0.4 m away from the wall. What is the vertical component of the force exerted by the rod on the board?



a. Less than 68 N
b. 68 – 70
c. 70 – 72
d. 72 – 74
e. 74 – 76
f. 76 – 78
g. 78 – 80
h. More than 80 N

$\sum \tau_A = 0$

$(F_{rod\,y})(.4m) - (mg)(1m) = 0$

$F_{rod\,y} = (mg)\left(\frac{1}{.4}\right)$

$= \frac{(3)(9.8)}{(.4)} = \boxed{73.5\,N}$

26. Mars has a radius of 53.3% of the earth's radius. Its mass is 10.7% of the earth's mass. Its orbit around the sun can be approximated as a circle with a radius 1.524× the radius of the earth's orbit. How does the surface gravitational acceleration (g) of Mars compare to the earth? g_{Mars} = ______ × g_{Earth}. (Some numbers for the earth are given on page 1, if needed.)

a. Less than 0.1
b. 0.1 – 0.2
c. 0.2 – 0.3
d. 0.3 – 0.4
e. 0.4 – 0.5
f. 0.5 – 0.6
g. 0.6 – 0.7
h. 0.7 – 0.8
i. 0.8 – 0.9
j. More than 0.9

F_G

$\sum F = ma$

$\frac{GM\cancel{m}}{r^2} = \cancel{m}a$

surface acceleration $= \frac{GM}{r^2}$

$\frac{g_{mars}}{g_{Earth}} = \frac{\cancel{G}M_{mars}/r_{mars}^2}{\cancel{G}M_{earth}/r_{earth}^2}$

$= (.107)\left(\frac{1}{.533}\right)^2$

$= \boxed{.3766}$

27. Same situation. How fast would you need to throw a ball on Mars, in order for it to escape Mars' gravitational pull?

a. Less than 4400 m/s
b. 4400 – 4500
c. 4500 – 4600
d. 4600 – 4700
e. 4700 – 4800
f. 4800 – 4900
g. 4900 – 5000
h. More than 5000 m/s

This is escape velocity

∞

$E_{bef} + \cancel{W} = E_{aft}$

$\frac{1}{2}\cancel{m}v_0^2 - \frac{GM\cancel{m}}{r} = 0 + 0$

$v_0 = \sqrt{\frac{2GM_{mars}}{r_{mars}}}$

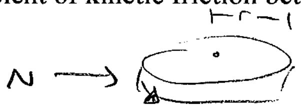
$= \sqrt{\frac{2\cdot(6.67\cdot10^{-11})(.107\cdot5.98\cdot10^{24})}{.533\cdot6.38\cdot10^{6}}} = \boxed{5010\,m/s}$

28. A certain CD spins up to speed due to a torque of 5 N·m. What happens to the CD's angular acceleration if the torque is increased to 10 N·m?
    a. It decreases by a factor of 4
    b. It decreases by a factor of 2
    c. It decreases by a factor of $\sqrt{2}$
    d. It stays the same
    e. It increases by a factor of $\sqrt{2}$
    f. It increases by a factor of 2
    g. It increases by a factor of 4

$\tau_{net} = I\alpha$

I is constant, so if τ doubles then α will also double

29. A potter's wheel has a radius of 0.5 m and a moment of inertia of 12.5 kg·m^2. It is rotating freely at 20 rad/s. The potter can stop the wheel in 7 s by pressing a wet rag against the rim and exerting a radially inward force of 80 N. Find the effective coefficient of kinetic friction between the wheel and the wet rag.
    a. Less than 0.55
    b. 0.55 – 0.60
    c. 0.60 – 0.65
    d. 0.65 – 0.70
    e. 0.70 – 0.75
    f. 0.75 – 0.80
    g. 0.80 – 0.85
    h. More than 0.85



$f = \mu N$

$\Sigma \tau = I\alpha$

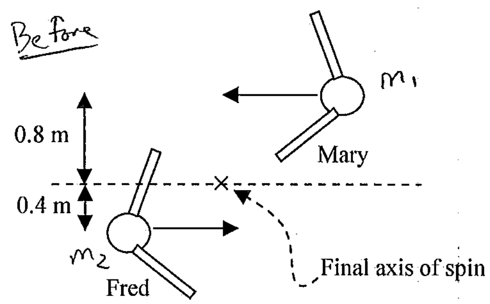
only torque is from friction

$(\mu N) r = I\alpha$

$\alpha = \frac{\Delta\omega}{\Delta t}$

$\mu = \frac{I\,\Delta\omega}{N r\,\Delta t} = \frac{(12.5)(20)}{(80)(.5)(7)} = \boxed{.893}$

Before



30. Fred and Mary—who formerly got into an argument on frictionless ice and pushed themselves apart—have now patched things up. They rush together with their trajectories separated by 1.2 m as shown. Fred (82 kg) has a speed of 3 m/s; Mary (41 kg) has a speed of 6 m/s. They join hands and begin to spin about an axis. Because there is no net momentum beforehand, they come to a complete stop aside from their spinning. Because Fred is twice as massive as Mary, the final axis about which they spin is twice as close to him as it is to Mary—0.8 m vs. 0.4 m, as in the figure. At what angular rate do they spin? (Approximate their bodies as point masses at those final positions.)
    a. Less than 7.2 rad/s
    b. 7.2 – 7.4
    c. 7.4 – 7.6
    d. 7.6 – 7.8
    e. 7.8 – 8.0
    f. 8.0 – 8.2
    g. 8.2 – 8.4
    h. 8.4 – 8.6
    i. More than 8.6 rad/s

$\Sigma L_{bef} = \Sigma L_{aft}$

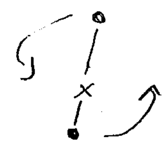
$L = r_\perp p \qquad L = I\omega$

$r_1 m_1 v_1 + r_2 m_2 v_2 = I_{tot}\,\omega$

$\omega = \frac{r_1 m_1 v_1 + r_2 m_2 v_2}{m_1 r_1^2 + m_2 r_2^2}$

$= \frac{(.8)(41)(6) + (.4)(82)(3)}{(41)(.8)^2 + (82)(.4)^2} = \boxed{7.5 \frac{rad}{s}}$

After



$I_{tot} = m_1 r_1^2 + m_2 r_2^2$