Name:________________ ID:_______________ Lab (day/time)___________

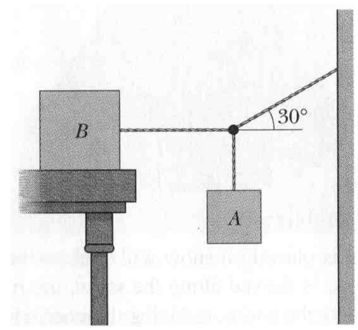
Physics 201

Final Exam

12/10/2014

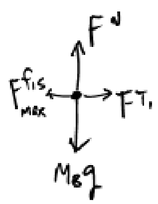
Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating/graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 110 minutes to complete this exam.

1. (10 points) Block **B** sitting on the table weighs 700 N. (a) If the coefficient of static friction between the block and the table is 0.3, what is the maximum weight for the hanging block **A**, for which the whole system will remain stationary? (b) What is the tension in the rope angled 30º above the horizontal when that max weight **A** is in place?



FBD (B)

$\hat{y}$ $\hat{x}$



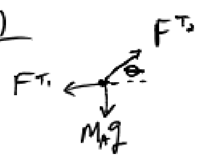
$\Sigma F_y \Rightarrow F^N - M_B g = M_B \cancel{a_{By}}^{\to 0} \Rightarrow F^N = M_B g$

$\Sigma F_x \Rightarrow F^{T_1} - \underbrace{\mu_s M_B g}_{F^{f,s}_{max} = \mu_s F^N} = M_B \cancel{a_{Bx}}^{\to 0} \Rightarrow F^{T_1} = \mu_s M_B g$

b/c M_A is max to not slip

FBD(A)

$\hat{y}$ $\hat{x}$



$\Sigma F_x \Rightarrow F^{T_2} \cos\theta - \underbrace{\mu_s M_B g}_{F^{T_1}} = M_A \cancel{a_{Ax}}^{\to 0}$

(b) $F^{T_2} = \dfrac{\mu_s M_B g}{\cos\theta} = 242\,N$

$\Sigma F_y \Rightarrow F^{T_2} \sin\theta - M_A g = M_A \cancel{a_{Ay}}^{\to 0}$

So Max $M_A = \mu_s M_B \tan\theta$ (a)

or w/ weights $\longrightarrow$ $M_{A\,max}\, g = 121\,N$

For questions 2 through 8 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **16** correct answers in this section and only the first **16** circled answers will be graded. There is no partial credit.

2. An object, *near* the surface of Earth, falls freely from rest under the influence of gravity. Which of the following statements are true concerning this situation? Neglect air resistance.

[F] (a) As the object falls, the net work done by all of the forces acting on the block is zero.
[T] (b) The kinetic energy increases by equal amounts over equal distances.
[T] (c) The momentum of the object increases by equal amounts in equal times.
[F] (d) The work from gravity on the object decreases by decreased amounts over equal distances.
[F] (e) The total mechanical energy of the block increases by decreased amounts over equal distances.

3. An object, *far* from the surface of Earth, falls freely from rest under the influence of gravity. Which of the following statements are true concerning this situation? Neglect air resistance.

[F] (a) As the object falls, the net work done by all of the forces acting on the block is zero.
[T] (b) The kinetic energy increases by increased amounts over equal distances.
[T] (c) The momentum of the object increases by increased amounts in equal times.
[F] (d) The work from gravity on the object decreases by decreased amounts over equal distances.
[F] (e) The total mechanical energy of the block increases by decreased amounts over equal distances.

4. Which of the following statements are true?

[F] (a) Normal forces acting on an object are always perpendicular to the direction of motion.
[F] (b) Normal forces always do zero work on an object.
[T] (c) Friction is always parallel to the surface between two objects.
[F] (d) Friction always does negative work on an object.
[F] (e) If the force from friction is non-zero, the object must be increasing or decreasing its kinetic energy.

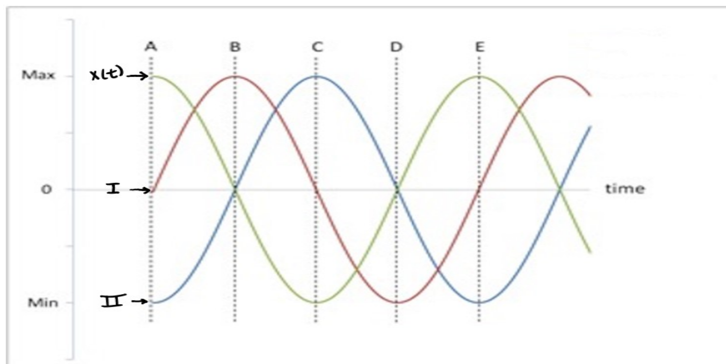
5. A truck is traveling east when it collides with a car traveling the north. The two do not stick together. Which of the following outcomes are not possible?

[P] (a) The car bounces off north of east and the truck also north of east.
[NP] (b) The car bounces off south and the truck south of east.
[NP] (c) The car bounces off east and the truck west.
[NP] (d) The car bounces off north and the truck south.
[P] (e) The car comes to rest and the truck bounces off north of east.
[P] (f) The truck comes to rest and the car bounces off north of east.

6. Two identical cars are traveling around different flat, circular tracks. The tracks apply the same magnitude force of friction to each of them when they both drive as fast as they can without slipping. The radius of the track car A travels around is 10 m larger than that of car B. Which of the following statements are true

[T] (a) Car A is driving faster than car B.
[F] (b) Car B is driving faster than car A.
[T] (c) Car A travels a further distance than car B over the same interval of time.
[F] (d) Car B travels a further distance than car A over the same interval of time.
[F] (e) The radial acceleration for car A is larger than that of car B.
[F] (f) The radial acceleration for car B is larger than that of car A.
[F] (g) The coefficient of static friction between the car and track in case A is larger than in B.
[F] (h) The coefficient of static friction between the car and track in case A is smaller than in B.
[T] (i) The coefficient of static friction between the car and track in case A is equal to B.

7. The figure shows several plots, one of which labeled as representing the position of a mass on a frictionless surface, connected to a horizontal spring that is vibrating back and forth. The other two plots are number I and II. Which of the following statements are false regarding these plots and this situation?

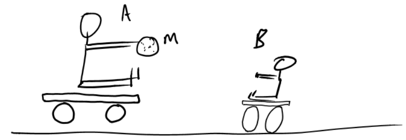


[F] (a) Plot I could represent the mass's velocity as a function of time.
[F] (b) Plot I represents the mass's acceleration as a function of time.
[T] (c) Plot II represents the mass's acceleration as a function of time.
[T] (d) The mass has the greatest amount of potential energy at points A, C, and E.
[F] (e) The mass has the greatest amount of kinetic energy at points A, C, and E.
[T] (f) The potential energy of the mass is maximum when its magnitude of acceleration is greatest.
[T] (g) The kinetic energy of the mass is greatest when its position is zero.

8. A woman is standing on a scale in an elevator at rest that reads her weight is equal to ***mg***. Sometime later she notes the scale reads less than ***mg***. Which of following statements can she conclude to be plausible (could be true) regarding this situation?

[NP] (a) She is moving downward at a constant speed.
[NP] (b) She is moving upwards at a constant speed.
[P] (c) She is moving upwards and slowing down.
[NP] (d) She is moving upwards and speeding up.
[NP] (e) She is moving downwards and slowing down.
[P] (f) She is moving downwards and speeding up.
[NP] (g) She is still at rest.

9. (10 points) Two people ($m_A > m_B$) are on low friction carts, throwing a medicine ball back and forth as depicted in the figure. (a) What is the sign of the work of the ball on person ***A*** while they catch the ball? (b) What is the sign of the work of the ball on the person ***A*** while they throw the ball? (c) After one full cycle of throwing the ball, the other person catching it and throwing it back, and then catching it, who has the greater final magnitude of momentum? (d) It can be shown that zero work is done on the composite ***AB*** system yet the speed of the two are continually increasing due to tossing the ball back and forth. How can this be - where is the kinetic energy coming from? Explain your reasoning for each part of the question.



$W = \vec{F} \cdot \Delta\vec{r} = |\vec{F}||\Delta\vec{r}|\cos\theta$

(a) while catching $\quad F^{mA}$, Δr, $\quad \theta = 0$, so W positive

or $\quad W = \Delta K$ + w/ KE positive, W positive

(b) while throwing $\quad F^{mA}$, $\Delta\vec{r}$, $\quad$ " $\quad$ " $\quad$ W positive

(c) if $M_m \ll M_A$, + (AB) system: $\Sigma F_{ext} = 0$, so $\Sigma\vec{P_i} = \Sigma\vec{P_f}$

+ $\Delta\vec{P_A} = -\Delta\vec{P_B}$

so $|\vec{P}_{fA}| = |\vec{P}_{fB}|$

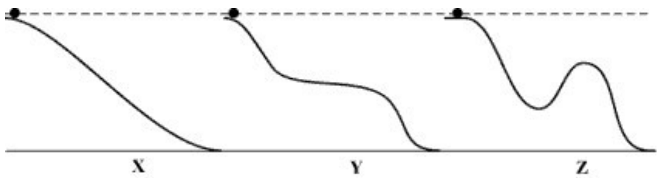
or Same $|\Sigma\vec{F}|\Delta t$ so, same $|\Delta\vec{P}|$

(d) Internal Work: $\quad U^{chem} \xrightarrow[\text{Via Muscle Work}]{} K$

10. (12 points) A ball can be rolled down one of four different ramps, as shown below. The final elevation loss of each of the ramps is the same. Rank the following quantities in reference to the ball, starting with the smallest:

$\Sigma E_i + \cancel{W_{nc}}^{0} = \Sigma E_f$

$\Delta U = -\Delta K$



(a) final speed,

$M_x = M_y = M_z$

$V_x = V_y = V_z$ b/c same ΔU + same ΔK

(b) final kinetic energy,

$K_x = K_y = K_z$

(c) time to reach the bottom,

$\Delta t_x < \Delta t_y < \Delta t_z$ b/c same ΔU but longer path

(d) final magnitude of momentum,

if $K_x = K_y = K_z$, w/ $K = \frac{|\vec{p}|^2}{2m}$, + m same, $|\vec{P}_x| = |\vec{P}_y| = |\vec{P}_z|$

(e) work from gravity from the top to the bottom,

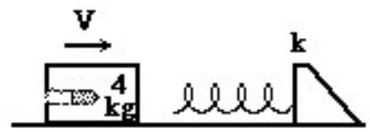
$W^g = -\Delta U^g$, $W^g_x = W^g_y = W^g_z$

(f) magnitude of average acceleration from the top to the bottom.

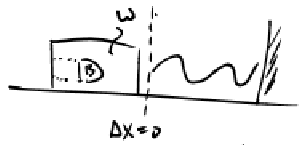
$|\vec{a}| = \frac{|\Delta \vec{v}|}{\Delta t}$, w/ $|\Delta \vec{v}|$ same, + $\Delta t_x < \Delta t_y < \Delta t_z$

$|\vec{a}_z| < |\vec{a}_y| < |\vec{a}_x|$

11. (10 points) An 8 g bullet is shot into a 4.0 kg block, at rest on a frictionless horizontal surface. The bullet remains lodged in the block. The block moves into a spring and compresses it by 3.7 cm. The force constant of the spring is 2500 N/m. (a) What was the velocity of the bullet right before embedding into the wood? (b) How much energy was converted to thermal energy during the collision with the block?



(a)



Collision w/ $\sum \vec{F}_{ext} \Delta t = 0$, $\sum \vec{P}_i = \sum \vec{P}_f$

$$M_B V_{iB} + M_W \cancel{V_{iW}}^{\,0} = (M_B + M_W) V_f$$

$$\underline{V_f = \frac{M_B}{M_B + M_W} V_{iB}}$$

Spring Compress $\sum E_i + \sum \cancel{W_{nc}}^{\,0} = \sum E_f$

$$\cancel{U^s_i}^{\,0} + K_i = U^s_f + \cancel{K_f}^{\,0}$$

$$V_f \; \frac{1}{2}(M_B + M_W) V_i^2 = \frac{1}{2} k \Delta X^2$$

collision

so $\underline{\frac{M_B^2}{(M_B + M_W)}} V_{iB}^2 = k \Delta X^2$, $\underline{|\vec{V}_{iB}| = 463 \text{ m/s}}$

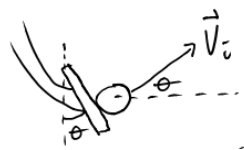
(b) during Collision $K \rightarrow E_{th}$

$$\Delta K = \frac{1}{2}(M_B + M_W) V_f^2 - \left(\frac{1}{2} M_B V_{iB}^2 + \frac{1}{2} M_W \cancel{V_{iW}^2}^{\,0}\right)$$

w/ $V_f = 0.924$ m/s, $\Delta K = -855$ J

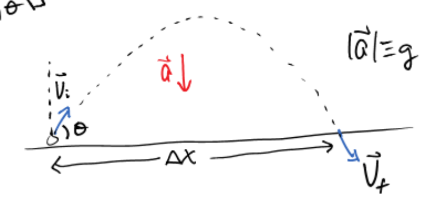
so $\underline{\Delta E_{th} = +855 \text{ J}}$

12. (15 points) Lion Forest, a universe-class golfer, can hit a ball with his 7-iron club 150 m pretty consistently on flat ground. His 7-iron makes an angle of 34º with respect to the vertical. (a) If he imparts the same *magnitude* impulse to his 5-iron, which makes an angle of 27º with respect to the vertical, how far will it travel? (If you use the range equation from the textbook, you must show how it is derived)
He has an upcoming tournament on the planet Omicron; a planet who's radius is one and a half times that of Earth but its mass is only 25% larger. (b) If he imparts the same impulse to the ball on each planet, how far will he hit the ball with his 7-iron on planet Omicron?



(a)

Projectile



$|\vec{a}| = g$

y-comp $\quad \cancel{\Delta y}^{0} = V_{iy}\Delta t + \frac{1}{2}a_y\Delta t^{\cancel{2}}$

$\Delta t = -\frac{2V_{iy}}{a} = \frac{2V_{iy}}{g}$

X-Comp $\quad \Delta x = V_{ix}\Delta t + \frac{1}{2}\cancel{a_x}^{0}\Delta t^2$

w/ $\theta_7 = 34°$, $\Delta x = 150\,m$, g_E, $m = 46\,g$

$|\vec{V}_i| = 39.82\,m/s$

$\Delta x = \frac{2V_{ix}V_{iy}}{g} = \frac{2|\vec{V}_i|^2 \sin\theta\cos\theta}{g}$

Same Magnitude Impulse

w/ $|\vec{P}| = m|\vec{V}|$ + m = constant, if $|\vec{P}_5| = |\vec{P}_7|$ then $|\vec{V}_5| = |\vec{V}_7|$

So, if $\theta_i = \theta_5 = 27°$ + Same initial speed

$\Delta X_5 = 131\,m$ ← note < ΔX_7 .... Spin + air resistance Really matter in this case

(b)

w/ Same Impulse ⇒ $\Delta\vec{P}$ + $\Delta\vec{V}$ same

So $\vec{V}_i$ @ hit same

+ $\Delta X \propto \frac{1}{g}$

Relating g's

$F_E^G = \underbrace{\frac{GM_E}{r_E^2}}_{g_E} m$, $F_o^G = \frac{GM_o}{r_o^2} m = \frac{G\left[\frac{5}{4}M_E\right]}{\left(\frac{3}{2}r_E\right)^2} m = \frac{5}{9} F_E^G$

So $g_o = \frac{5}{9} g_E$

w/ $\Delta X \propto \frac{1}{g}$, if $g \to \frac{5}{9} g$, $\Delta X \to \frac{9}{5}\Delta X$

So $\Delta X_o = \frac{9}{5}\Delta X_E = 270\,m$

Scores:

Problems

1	2-8	9	10	11	12

Exam Total