PHYSICS 211——PRACTICE EXAM 2 (2008 VERSION)

NAME (printed) KEY For Wednesday.

SIGNATURE ______________________

Student Number (SSN) ______________________

SECTION ______________________

INSTRUCTIONS

1) Wait for oral instructions before starting the test.

2) Remember to justify (in English) as many steps as possible for partial credit.

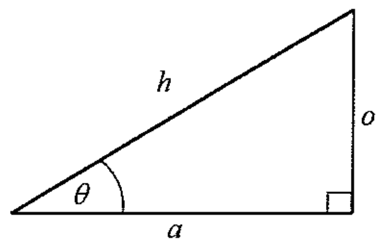
3) No calculators or other aids permitted.

4) You must show your working on part d of each problem

For the graders:

1. ______
2. ______
3. ______
4. ______

TOTAL ______



$$\sin\theta = o/h$$
$$\cos\theta = a/h$$
$$\tan\theta = o/a$$

$$\sin(90^\circ - \theta) = \cos\theta \qquad \cos(90^\circ - \theta) = \sin\theta$$

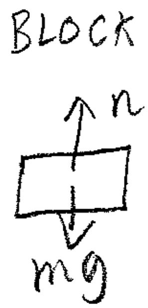
$$\begin{aligned} \sin 0 &= 0 & \cos 0 &= 1 \\ \sin 90^\circ &= 1 & \cos 90^\circ &= 0 \\ \sin 30^\circ &= 1/2 & \cos 60^\circ &= 1/2 \end{aligned}$$

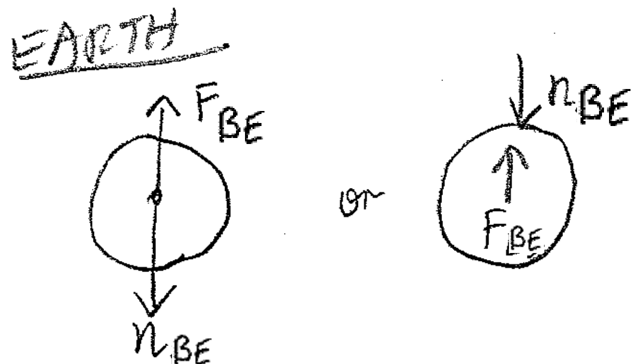
$$2\sin\theta\cos\theta = \sin 2\theta$$

1. a) A concrete block of mass m rests on the Earth's (horizontal) surface. There are four forces involved:

mg the gravitational attraction of the earth on the block
n the normal force of the earth on the block
F_{BE} the gravitational attraction of the block on the earth
n_{BE} the normal force of the block on the earth

Draw and label two free body diagrams, one for the block and the other for the earth. *[4 points]*





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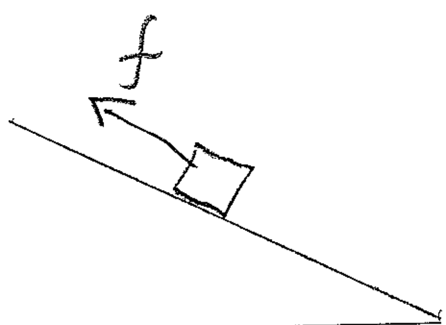
b) Write down the two action-reaction pairs. *[4 points]*

1) n and n_{BE}

2) mg and F_{BE}

4

c) An object is sliding down a ramp, even though there is friction present. Draw the ramp with a single arrow showing the direction of the frictional force. *[4 points]*



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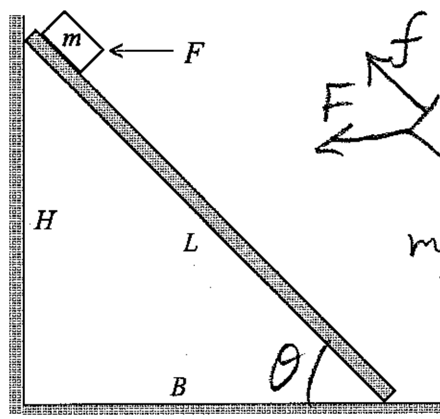
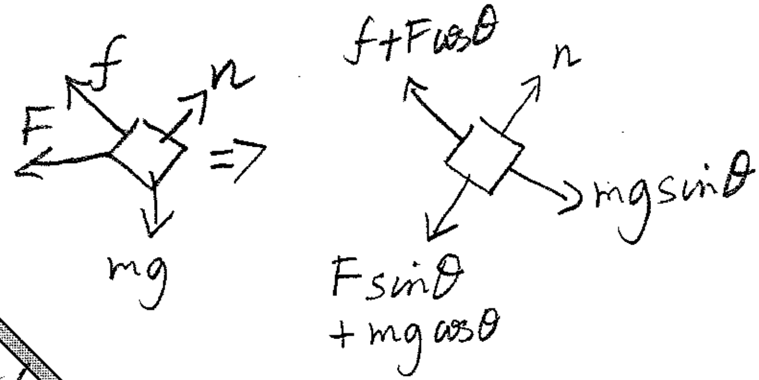
1. d) An object of mass $m = 6$ kg is placed at the top of a ramp, as shown below. The friction is not enough to keep it there so a horizontal force F is applied. The coefficient of static friction is $\mu_s = 1/3$. The height of the ramp is $H = 30$ m, its base is $B = 40$ m, and its length is $L = 50$ m. What is the minimum force F required? Take $g = 9.8$ m/s^2. *[HINT: Be careful! F changes the frictional force.] [13 points]*

FBD





So $n = F\sin\theta + mg\cos\theta$

$f = \mu_s n = \mu_s(F\sin\theta + mg\cos\theta)$ for min. F

Also
$$mg\sin\theta = F\cos\theta + f$$
$$= F\cos\theta + \mu_s(F\sin\theta + mg\cos\theta)$$
$$= F(\cos\theta + \mu_s\sin\theta) + \mu_s mg\cos\theta.$$

Then
$$F = \frac{mg(\sin\theta - \mu_s\cos\theta)}{(\cos\theta + \mu_s\sin\theta)} = \frac{mg(H - \mu_s B)}{B + \mu_s H}$$

$$F = \frac{6 \times 9.8 \times \left(30 - \frac{40}{3}\right)}{40 + 30/3} = 6 \times 9.8 \times \left(\frac{3 - \frac{4}{3}}{4+1}\right)$$

$$= \overset{2}{\cancel{6}} \times 9.8 \times \frac{\cancel{5}}{\cancel{3} \times \cancel{5}} = 19.6$$

$$\boxed{F = 19.6\ N}$$

2. a) If a force F acts on an object over a distance d, and the force and displacement are in the *opposite* direction, what is the work W done by the force? *[4 points]*

$$W = -Fd$$

4

b) If a force F acts on an object over a distance d, and the force and displacement are *perpendicular* to one another, what is the work W done *by* the force on the object? *[4 points]*

$$W = 0$$

4

c) (i) What is the change in gravitational potential energy of an object of mass m that is slid up a ramp of length L and height h in the Earth's gravitational field? *[2 points]*

$$mgh$$

2

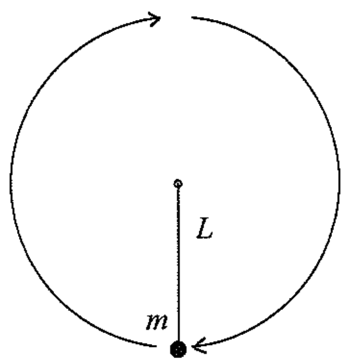
(ii) What is the total change in gravitational potential energy of the same object if it is slid up the ramp and then pushed over the top so it falls vertically down to the ground? *[2 points]*

$$0$$

2

2. d) A mass m is attached to one end of a massless stick of length L that is pivoted about the other end, as shown below. A force of constant magnitude F_0 is applied to the mass in a direction always perpendicular to the stick (Like a sideways pointing rocket tied to the stick). The mass, which starts at rest, thus executes circular motion in the vertical plane, as shown below.

Derive an expression in terms of F_0, m, L for its speed when it has completed a full circle. *[HINT: What is the total work done by all the forces, and what does the work-energy theorem say about $\Delta(KE)$?] [13 points]*



$W_{NET} = W_{GRAVITY} + W_{ROCKET}$.

$W_{GRAVITY} = 0$ since it comes back to where it started.

$W_{ROCKET} = F_0(2\pi L) = W_{NET} = \frac{1}{2} m v^2$.

$\therefore \quad v = \sqrt{\frac{4\pi L F_0}{m}}$

13

3. a) What is the kinetic energy of an object of mass m moving with velocity v? *[4 points]*

$$\frac{1}{2} m v^2$$

4

b) If a spring, of spring constant k and fixed to a wall at one end, is compressed by an amount x, what is the force F exerted on an object placed at the "free" end of the spring. Ignore signs. *[4 points]*

$$F = kx$$

or $F = -kx$

4

c) What is the potential energy stored in the spring when it is compressed by an amount x? *[4 points]*

$$PE = \frac{1}{2} k x^2$$

4

3. d) A spring is mounted vertically on a table. An object of mass m is placed on the (uncompressed) spring and gently lowered until the spring supports the object. The spring is found to have been compressed by $x = 2.1m$ (It's a long spring!) *[This gives you an expression containing the spring constant]*

The object is lifted up until the spring is again (just) uncompressed. The object is then released and allowed to "free fall", thereby compressing the spring. How much is the spring compressed before the object comes to rest? (It then "bounces", but that is not of interest here). *[Hint: Use potential energy and the conservation of mechanical energy]. [13 points]*

First part

$(F = kx)$ up and $(F = mg)$ down.

$\therefore kx_1 = mg \quad (x_1 = 2.1\,m)$

Second Part

When object comes to rest, gravitational potential energy has been converted to "spring" potential energy

$\therefore mgx_2 = \frac{1}{2}kx_2^2$

Cancel x_2, giving $2mg = kx_2$

From the first part $mg = kx_1$

$\therefore kx_2 = 2kx_1$ or $x_2 = 2x_1$

$\therefore \boxed{x_2 = 4.2\,m}$

13

4 **Collisions**. A particle of mass m_1 and speed v_1 collides with a particle of mass m_2 and speed v_2. After the collision their speeds are v_1' and v_2'.

a) If the collision is **elastic** write down the Conservation of Momentum for this case. *[4 points]*

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

4

b) If the collision is **elastic** write down the conservation of mechanical energy for this case. *[4 points]*

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2$$

4

[OK without $\frac{1}{2}$'s]

c) (i) What conservation law (derived from Newton's third law) is true for *any* collision? (One word.) *[2 points]*

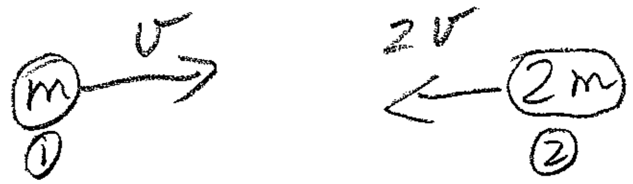
Momentum

2

(ii) Two objects of equal mass m are traveling towards eachother with equal speed. They collide head on in a **perfectly inelastic** collision. What is their speed after the collision? *[2 points]*

0

2



4. d) Object 1 of mass m is traveling to the right with speed v. It collides elastically with object 2 of mass $2m$ that is in front of it traveling to the left with speed $2v$. Find the final velocities v_1' and v_2' of the two objects. Express your answers in terms of v and state whether each object is traveling to the left or the right. (*You may use the fact that the sum of the initial and final velocities of object 1 is equal to the sum of the initial and final velocities of object 2.*) *[13 points]*

Right = +
Left = −

Conservation of Momentum gives :−

$$mv - (2m)(2v) = mv_1' + (2m)v_2'$$

or $-3\cancel{m}v = \cancel{m}(v_1' + 2v_2')$ ①

Also

$$v + v_1' = -2v + v_2'$$

$$\therefore v_1' = -3v + v_2' \quad ②$$

Use ② in ① to eliminate v_1' :−

$$-\cancel{3v} = \cancel{-3v} + 3v_2'$$

$$\therefore \boxed{v_2' = 0}$$ (Neither left nor right)

From ②

$$\boxed{v_1' = -3v}$$ (To Left)

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