Kuwait University

Physics Department
Physics 101

I

Second Midterm Exam
Summer 2008
Thursday, July 24th, 2008
6:00 p.m. – 7:30 p.m.

Student's Name: ……………………………MODEL ANSWER……………………………

Student's Number: ……………………………………………………………………

Choose your Instructor's Name:

Drs. Al-DOSSARI Fatma, AL-JASSAR Ahmed, AL-JASSAR Halah.,

AL-REFAE Tarek, AL-YASEEN Adnan, EL-AKKAD Fikry, ZAHER Ashraf.

Grades:

#	Q1	Q2	Q3	Q4	P1	P2	P3	P4	P5	P6	P7	P8	Total
Points													

Important:
1. Answer all questions and problems.
2. Each question will be assigned 1 point.
3. Each problem will be assigned 2 points.
4. No solution = no points.
5. Check the correct answer for each question.
6. Assume $g = 10\ m/s^2$.
7. Mobiles and Pagers are not allowed during the exam.
8. Programmable calculators, which can store equations, are not allowed.

GOOD LUCK

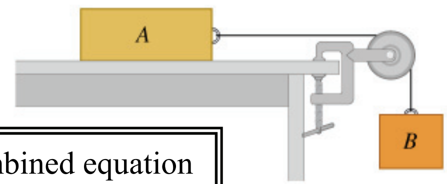
Part I: Questions (Choose the correct answer)

1. Which of the following is an accurate statement?

(a) **Kinetic energy is always positive.**
(b) Potential energy is always positive.
(c) Mechanical energy is always positive.
(d) None of the above.

Only kinetic energy can be positive because it depends on the square of the velocity.

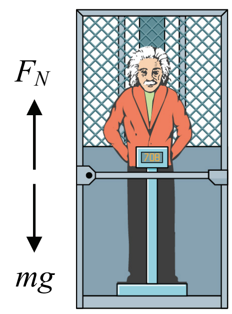
2. Two blocks, initially at rest, are connected by a string that passes over a frictionless massless pulley, as shown in figure. If block A has a mass m_A = 10 kg and moves on a frictionless surface, then block B will move downward if



(a) $m_B = 5$ kg.
(b) $m_B = 10$ kg.
(c) $m_B = 20$ kg.
(d) **all of the above.**

Since there is no friction, the combined equation of motion is $m_B g = (m_A+m_B)a$. Thus, any value of m_B will cause the system to move.

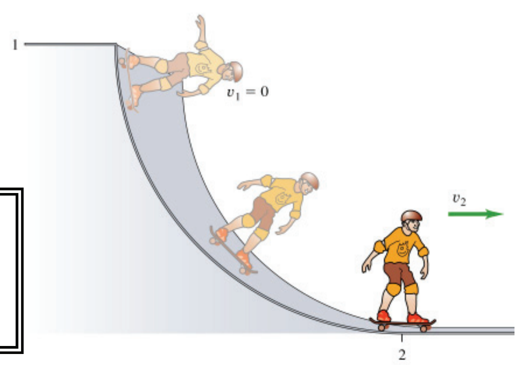
3. A 65-kg man stands on a scale while riding in an elevator, as shown in figure. If the reading of the scale is 80-kg, then



(a) **the elevator is accelerating upward.**
(b) the elevator is accelerating downward.
(c) the elevator is decelerating upward.
(d) the elevator is moving at a constant speed.

Since $F_N > mg$, the acceleration must be upward.

4. The skateboarder, with mass m, shown in figure, travels along a curved, frictionless circular track with radius R. The total work done by the normal force is

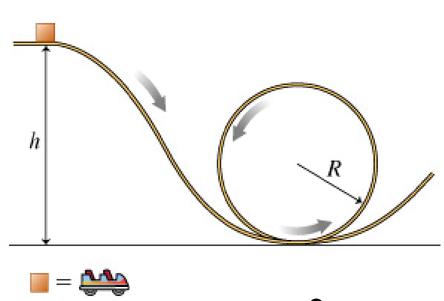


(a) $mg \times R\sqrt{2}$.
(b) $mg \times R$.
(c) $mg \times 0.5\pi R$.
(d) **zero.**

F_N is always perpendicular to the track, so its work must be zero ($W = \int F \cdot ds$).

Part II: Problems (solve the following problems)

1. For the rollercoaster, shown in figure, a car with mass m = 50 kg starts at rest at a height h = 30 m and slides without friction into a loop of radius R = 10 m. Find the magnitude of the normal force (in N) when the car passes through the top of the loop.

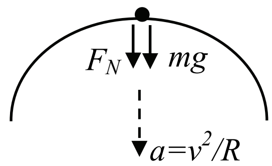


$$mgh = 2mgR + 0.5mv_{top}^2$$

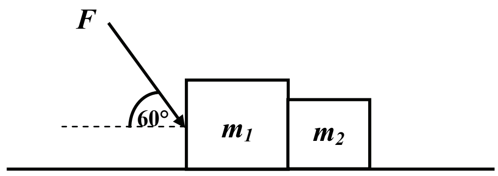
$$v_{top}^2 = 2g(h-2R) = 2\times10(30-2\times10) = 200\ m^2/s^2$$

$$F_n + mg = m\frac{v_{top}^2}{R}$$

$$F_n = m(\frac{v_{top}^2}{R} - g) = 50\times(\frac{200}{10} - 10) = 500\ \text{N}$$



2. Two blocks at rest, $m_1 = 3$ kg and $m_2 = 2$ kg are in perfect contact with each other and placed on a frictionless surface. When a force F is applied to the system, as shown in figure, for a distance $d = 5$ m, the change in kinetic energy for m_2 is 100 J. Find the magnitude of the force F (in N).



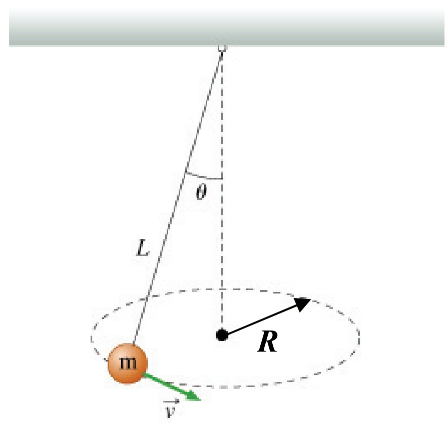
$$W = \Delta K = K_2 - K_1 = K_2$$

$$F\cos\theta \times \Delta x = 0.5(m_1 + m_2)v^2 = \frac{(m_1 + m_2)}{m_2}(0.5 m_2 v^2)$$

$$F = \frac{(m_1 + m_2)}{m_2 \Delta x \cos\theta}(0.5 m_2 v^2)$$

$$= \frac{(3+2)}{2\times 5\times 0.5}\times 100 = 100 \text{ N}$$

3. The conical pendulum, shown in figure, has circular radius $R = 0.40$ m and a mass $m = 0.2$ kg, and makes 30 revolutions per minute. Find the tension (in N) in the string.



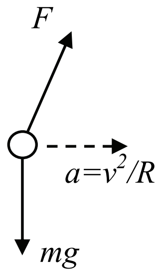
$$30 \text{ Rev.} \Rightarrow 60 \text{ s}$$

$$1 \text{ Rev.} \Rightarrow T = 2 \text{ s}$$

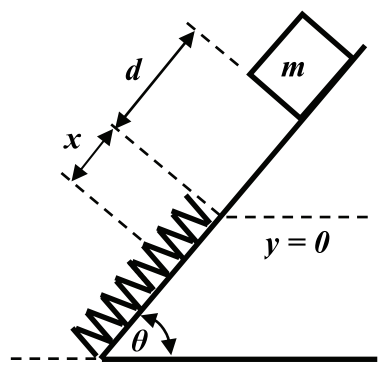
$$v = \frac{2\pi R}{T} = \frac{2\pi \times 0.4}{2} = 1.257 \text{ m/s}$$

$$\left.\begin{aligned} F\sin\theta &= mv^2/R \\ F\cos\theta &= mg \end{aligned}\right\} \Rightarrow F = m\sqrt{\frac{v^4}{R^2} + g^2}$$

$$F = 0.2\times\sqrt{\frac{1.257^4}{0.4^2} + 10^2} = 2.15 \text{ N}$$



4. A block with mass $m = 1$ kg starts from rest and slides down a rough incline at an angle $\theta = 50°$ with the horizontal, as shown in figure. The block is initially at a distance $d = 0.2$ m from a spring with force constant $k = 400$ N/m. Find the coefficient of kinetic friction, μ_k, if the spring compresses a maximum distance $x = 0.10$ m.



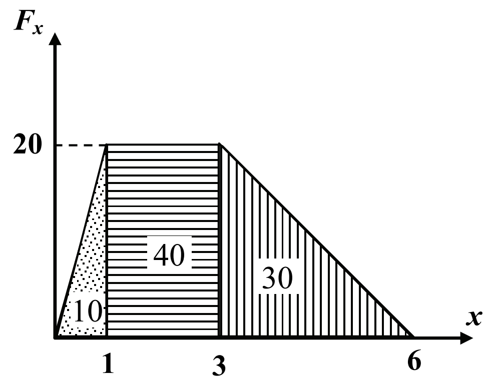
$$E_1 + W_{others} = E_2 \Rightarrow E_1 + W_{Friction} = E_2$$

$$mgd\sin\theta - \mu_k mg\cos\theta(d+x) = -mgx\sin\theta + 0.5kx^2$$

$$\mu_k = \frac{mg\sin\theta(d+x) - 0.5kx^2}{mg\cos\theta(d+x)}$$

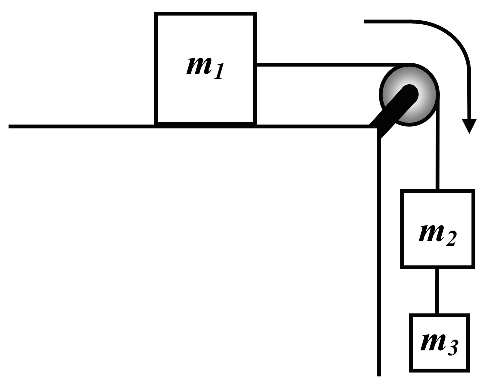
$$= \frac{1\times 10\times\sin(50^\circ)\times(0.2+0.1) - 0.5\times 400\times 0.1^2}{1\times 10\times\cos(50^\circ)\times(0.2+0.1)} = 0.155$$

5. A particle moving along the x-axis is acted upon by a variable force F_x (in N), as shown in figure. If the particle starts at x = 0 and reaches x = 6 m after 20 seconds, find the average power (in W) during this time interval.



$$P_{avg} = \frac{\Delta W}{\Delta t} = \frac{\text{Area under the graph}}{\Delta t}$$
$$= \frac{10 + 40 + 30}{20}$$
$$= 4\ \text{W}$$

6. A system of three blocks moves in the direction shown in figure, with constant acceleration a = 2 m/s^2. The mass m_1 moves on a rough horizontal surface. If m_3 is removed from the system, m_2 will move downward with constant speed. Find the mass m_3 (in kg) knowing that m_1 = 5 kg and m_2 = 3 kg.



With $m_3 : (m_2 + m_3)g - \mu_k m_1 g = (m_1 + m_2 + m_3)a \quad \Rightarrow (1)$

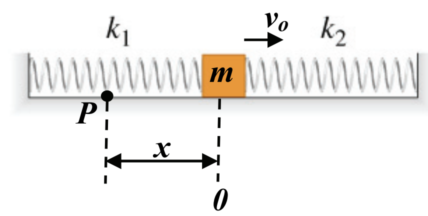
Without $m_3 : m_2 g - \mu_k m_1 g = 0 \quad \Rightarrow (2)$

From (2) : $\mu_k = \frac{m_2}{m_1} = 0.6 \quad \Rightarrow (3)$

From (3) in (1) : $(3 + m_3 - 0.6 \times 5) \times 10 = (8 + m_3) \times 2$

$m_3 = 2\ \text{kg}$

7. A block of mass m = 1 kg is connected to two long horizontal springs of force constants k_1 = 40 N/m and k_2 = 60 N/m, as shown in figure. The block is given an initial velocity v_o = 5 m/s to the right. Find its speed (in m/s) at the point P (x = 0.3 m) knowing that the surface is frictionless.



$$E_1 + W_{others} = E_2$$

$$0.5mv_0^2 + 0 = 0.5mv_P^2 + 0.5k_1x^2 + 0.5k_2x^2$$

$$v_P = \sqrt{mv_0^2 - (k_1 + k_2)x^2}$$

$$= \sqrt{1 \times 5^2 - (40 + 60) \times 0.3^2} = 4 \text{ m/s}$$

8. An object of mass m = 2 kg, moving along the y-axis, is acted upon by a conservative force, $F(y)$, described by the potential energy function $U(y) = 20\,y + 25\,y^2$, where y in meters and U in joules. Find its speed (in m/s) when both the mechanical energy $E(y)$ and $F(y)$ vanish, (i.e. $E = 0$ and $F(y) = 0$).

$$F(y) = -\frac{dU(y)}{dy} = -20 - 50y = 0 \Rightarrow y = -0.4 \text{ m}$$

$$U(y = -0.4) = 20 \times -0.4 + 25 \times (-0.4)^2 = -4 \text{ J}$$

$$E = U + K \Rightarrow E(y = -0.4) = U(y = -0.4) + 0.5mv^2$$

$$0 = -4 + 0.5 \times 2 \times v^2 \Rightarrow v = 2 \text{ m/s}$$