The follow ular arithi	Arithmetic. ving problems are intended to give you some practice and familiarity with modmetic computations, and to make you comfortable with the Euclid's Algorithm otion of multiplicative inverses modulo m .
	culate the smallest non-negative $x \in \mathbb{N}$ for each of the following expressions: $x = 21 \mod 12$ $x = 1$ Recall to compute $a \mod b$, we divide $a \bowtie b \bowtie b$ to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
	answer is $x = r$. We can express 21 as $12 \times 1 + 9$, so the remainder 9 is the solution. The equivalence class of 9 mod 12 is $\{15, -3, 9, 21, 33\}$, obtained by adding integer multiples of 12 to 9. (Note that in this case it might have been
(b)	easier to notice that 21 was 3 less than a multiple of 12: $21 = 12 \times 2 + (-3)$. To convert a fully simplified negative answer like this to an answer in the range $0 \le x < 12$, simply add the modulus 12: $-3 + 12 = 9$). $x = -27 \mod 4$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
(c)	answer is $x = r$. We can express -27 as $4 \times (-7) + 1$, so the remainder 1 is the solution. The equivalence class of 1 mod 4 is $\{ 7, -3, 1, 5, 9\}$, obtained by adding integer multiples of 4 to 1. $x = 7 \mod 64$
	$x=$ Recall to compute $a \mod b$, we divide a by b to write $a=b\lfloor \frac{a}{b}\rfloor+r$. The answer is $x=r$. We can express 7 as $64\times 0+7$, so the remainder 7 is the solution. The equivalence class of 7 mod 64 is $\{121, -57, 7, 71, 135\}$, obtained by
(d)	adding integer multiples of 64 to 7. $x = 101 \mod 2$ $x = $ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
(e)	answer is $x = r$. We can express 101 as $2 \times 50 + 1$, so the remainder 1 is the solution. The equivalence class of 1 mod 2 is simply all of the odd integers. $x = 55 \mod 5$ $x = 65 \mod 5$
	Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$. We can express 55 as $5 \times 11 + 0$, so the remainder 0 is the solution. The equivalence class of 0 mod 5 is $\{10, -5, 0, 5, 10\}$, obtained by adding
(f)	integer multiples of 5 to 0. $x = 63 \mod 13$ $x =$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$
	answer is $x = r$. We can express 63 as $13 \times 4 + 11$, so the remainder 11 is the solution. The equivalence class of 11 mod 13 is $\{15, -2, 11, 24, 37\}$, obtained by adding integer multiples of 13 to 11. (Note that in this case it might have been easier to notice that 63 was 2 less than a multiple of 13: $63 = 13 \times 5 + (-2)$.
(g)	To convert a fully simplified negative answer like this to an answer in the range $0 \le x < 13$, simply add the modulus 13 : $-2 + 13 = 11$). $x = -25 \mod 7$ $x = -25 \mod 7$
	Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$. We can express -25 as $7 \times (-4) + 3$, so the remainder 3 is the solution. The equivalence class of 3 mod 7 is $\{11, -4, 3, 10, 17\}$, obtained by adding integer multiples of 7 to 3.
(h)	$x = -61 \mod 10$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$. We can express -61 as $10 \times (-7) + 9$, so the remainder 9 is the solution. The equivalence class of 9 mod 10 is $\{-11, -1, 9, 19, \}$ obtained by adding
	equivalence class of 9 mod 10 is $\{11, -1, 9, 19\}$, obtained by adding integer multiples of 10 to 9. (Note that in this case it might have been easier to notice that -61 was 1 less than a multiple of 10: $-61 = 10 \times (-6) + (-1)$. To convert a fully simplified negative answer like this to an answer in the range $0 \le x < 10$, simply add the modulus $10: -1 + 10 = 9$).
(i)	$x=20 \mod 1$ $x=\text{Recall to compute } a \mod b$, we divide a by b to write $a=b\lfloor \frac{a}{b}\rfloor+r$. The answer is $x=r$. We can express 20 as $1\times 20+0$, so the remainder 0 is the solution. All integers are in the equivalence class $0 \mod 1$, because all integers are perfect multiples
(j)	of 1. $x = 89 \mod 5$ $x =$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
	answer is $x = r$. We can express 89 as $5 \times 17 + 4$, so the remainder 4 is the solution. The equivalence class of 4 mod 5 is $\{6, -1, 4, 9\}$, obtained by adding integer multiples of 5 to 4. (Note that in this case it might have been easier to notice that 89 was 1 less than a multiple of 5: $89 = 5 \times 18 + (-1)$. To
(k)	convert a fully simplified negative answer like this to an answer in the range $0 \le x < 5$, simply add the modulus 5: $-1 + 5 = 4$). $x = -32 \mod 6$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
	answer is $x = r$. We can express -32 as $6 \times (-6) + 4$, so the remainder 4 is the solution. The equivalence class of 4 mod 6 is $\{8, -2, 4, 10, 16\}$, obtained by adding integer multiples of 6 to 4. (Note that in this case it might have been easier
(1)	to notice that -32 was 2 less than a multiple of 6: $-32 = 6 \times (-5) + (-2)$. To convert a fully simplified negative answer like this to an answer in the range $0 \le x < 6$, simply add the modulus 6: $-2 + 6 = 4$). $x = 34 \mod 16$
	Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$. We can express 34 as $16 \times 2 + 2$, so the remainder 2 is the solution. The equivalence class of 2 mod 16 is $\{ 30, -14, 2, 18, 34\}$, obtained by adding integer multiples of 16 to 2
(m)	adding integer multiples of 16 to 2. $x = 79 \mod 4$ $x =$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$.
	We can express 79 as $4 \times 19 + 3$, so the remainder 3 is the solution. The equivalence class of 3 mod 4 is $\{5, -1, 3, 7, 11\}$, obtained by adding integer multiples of 4 to 3. (Note that in this case it might have been easier to notice that 79 was 1 less than a multiple of 4: $79 = 4 \times 20 + (-1)$. To convert a fully simplified negative answer like this to an answer in the range
(n)	$0 \le x < 4$, simply add the modulus 4: $-1 + 4 = 3$). $x = -37 \mod 5$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The answer is $x = r$.
	We can express -37 as $5 \times (-8) + 3$, so the remainder 3 is the solution. The equivalence class of 3 mod 5 is $\{7, -2, 3, 8\}$, obtained by adding integer multiples of 5 to 3. (Note that in this case it might have been easier to notice that -37 was 2 less than a multiple of 5: $-37 = 5 \times (-7) + (-2)$. To convert a fully simplified negative answer like this to an answer in the range
(o)	$0 \le x < 5$, simply add the modulus 5: $-2 + 5 = 3$). $x = 17 \mod 3$ $x = 10$ Recall to compute $a \mod b$, we divide a by a to write $a = a + b \lfloor \frac{a}{b} \rfloor + r$. The analysis $a = r$
	answer is $x = r$. We can express 17 as $3 \times 5 + 2$, so the remainder 2 is the solution. The equivalence class of 2 mod 3 is $\{4, -1, 2, 5, 8\}$, obtained by adding integer multiples of 3 to 2. (Note that in this case it might have been easier to notice that 17 was 1 less than a multiple of 3: $17 = 3 \times 6 + (-1)$. To
(p)	convert a fully simplified negative answer like this to an answer in the range $0 \le x < 3$, simply add the modulus 3: $-1 + 3 = 2$). $x = -45 \mod 47$ Recall to compute $a \mod b$, we divide a by b to write $a = b \lfloor \frac{a}{b} \rfloor + r$. The
2 Dogi	answer is $x = r$. We can express -45 as $47 \times (-1) + 2$, so the remainder 2 is the solution. The equivalence class of 2 mod 47 is $\{ 92, -45, 2, 49, 96\}$, obtained by adding integer multiples of 47 to 2.
$a \equiv$	ide whether each of the following statements are true or false. The expression $b \mod 5$ reads " a is equivalent to $b \mod m$ ". $10 \equiv 2 \mod 5$ • True
(b)	• False Recall $a \equiv b \mod m$ iff m divides $a - b$. $10 - 2 = 7$, which is not divisible by 5, so $10 \not\equiv 2 \mod 5$ $42 \equiv 7 \mod 5$
	• True • False Recall $a \equiv b \mod m$ iff m divides $a - b$. $42 - 7 = 35$, which is divisible by 5, so $42 \equiv 7 \mod 5$
(c)	$18 \equiv -4 \mod 11$ • True • False Recall $a \equiv b \mod m$ iff m divides $a - b$.
(d)	$18 - (-4) = 22$, which is divisble by 11, so $18 \equiv -4 \mod 11$ $12 \equiv -6 \mod 5$ • True • False
(e)	Recall $a \equiv b \mod m$ iff m divides $a-b$. $12-(-6)=18$, which is not divisble by 5, so $12 \not\equiv -6 \mod 5$ $28 \equiv 14 \mod 7$ • True
(f)	• False Recall $a \equiv b \mod m$ iff m divides $a - b$. $28 - 14 = 14$, which is divisble by 7, so $28 \equiv 14 \mod 7$ $-37 \equiv 37 \mod 6$
	 True False Recall a ≡ b mod m iff m divides a - b. -37 - 37 = -74, which is not divisble by 6, so -37 ≠ 37 mod 6. Note
(g)	that it is <i>not</i> in general true that $a \equiv -a \mod m!$ $44 \equiv -44 \mod 8$ • True • False
(h)	 44 - (-44) = 88, which is divisble by 8, so 44 ≡ -44 mod 8. Note that it is not in general true that a ≡ -a mod m! (Why does it work here?) -17 ≡ -29 mod 4 True
	• False $-17 - (-29) = 12$, which is divisible by 4, so $-17 \equiv -29 \mod 4$. he notes, you learn that x has a multiplicative inverse $\mod m$ if and only if greatest common divisor of x and m is 1. For each of the following questions,
first inve- case	decide if x has a multiplicative inverse $\mod m$, then calculate y to be the rse of x in base m (if one exists), or give y such that $xy = 0 \mod m$. In all $x = 3, m = 5$.
	What is $gcd(x, m)$? Review the definition and existence conditions of an inverse modulo m in the notes. • x has an inverse mod m . • x does not have an inverse mod m .
	Yes, $gcd(x,m) = gcd(3,5) = 1$ y = What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. Since 3 and 5 are small values, we can use guess-and-check to see that 2 is
(b)	the multiplicative inverse $(3 \times 2 = 6 \equiv 1 \mod 5)$. This answer is unique mod5, so other numbers in the equivalence class $(7, 12, 17, \text{ etc})$ would also work. $x = 3, m = 6$.
` ,	Review the definition and existence conditions of an inverse modulo m in the notes. • x has an inverse $\mod m$. • x does not have an inverse $\mod m$.
	No, $gcd(x, m) = gcd(3, 6) = 3$. The numbers are not coprime, so no inverse exists. $y =$ What is $gcd(x, m)$? Review the definition and existence conditions of an inverse modulo m in the notes.
(c)	We want to find y such that $3y \equiv 0 \mod 6$. By trial and error we find that $2 \pmod 3 \times 2 = 6 \equiv 0 \mod 6$. Any multiple of $2 \pmod 3$ would also work. $x = 15, m = 4$. Review the definition and existence conditions of an inverse modulo m in the
	notes. • x has an inverse $\mod m$. • x does not have an inverse $\mod m$. Yes, $gcd(x,m) = gcd(15,4) = 1$, so an inverse exists.
	y= What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We know $15^{-1} \mod 4 = (15 \mod 4)^{-1} \mod 4 = 3^{-1} \mod 4$. From trial and error we can see that $3 \text{ works } (3 \times 3 = 9 \equiv 1 \mod 4)$. Quickly verifying, we
(d)	see that $15 \times 3 = 45 \equiv 1 \mod 4$. Anything in the same equivalence class $(7, 11, 15, \text{ etc})$ would also work. $x = 3, m = 4$. Review the definition and existence conditions of an inverse modulo m in the
	notes. • x has an inverse $\mod m$. • x does not have an inverse $\mod m$. Yes, $gcd(x,m) = gcd(3,4) = 1$, so an inverse exists.
(0)	y = What is $gcd(x, m)$? Review the definition and existence conditions of an inverse modulo m in the notes. From above, we found $3^{-1} \mod 4 = 3$, or anything equivalent to $3 \mod 4$.
(e)	 x = 12, m = 16. Review the definition and existence conditions of an inverse modulo m in the notes. x has an inverse mod m. x does not have an inverse mod m.
	No, $gcd(x, m) = gcd(12, 16) = 4$. The numbers are not coprime, so no inverse exists.
	y = What is $gcd(x, m)$? Review the definition and existence conditions of an inverse module m in the notes
4. Eucl	What is $gcd(x, m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12, 16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work.
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So g find	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. It is algorithm is a fast algorithm for computing the greatest common divisor wo integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (\text{notice this is a recursive call of } gcd(10,6)) \qquad (2)$ $6 = 4 \times 1 + 2 \qquad (\text{notice this is a recursive call of } gcd(6,4)) \qquad (3)$ $4 = 2 \times 2 + 0 \qquad (\text{notice this is a recursive call of } gcd(4,2)) \qquad (4)$ $10 \times gcd(16,10) = 2, \text{ the last non-zero remainder. We can also back substitute to } x, y \text{ such that}$ $2 = 16x + 10y = gcd(16,10).$ The is how: Rearrange (3) to get an expression for $gcd(16,10)$: $2 = 6 - 4 \times 1$ $2 = 6 - (10 - 6 \times 1) \times 1$ $3 = 6 + (10 - 6 \times 1) \times 1$ $4 = 6 + (10 - 6 \times 1) \times 1$
So g find Here	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 5$ an untiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. Itid's algorithm is a fast algorithm for computing the greatest common divisor we integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad \text{(notice this is a recursive call of } gcd(10,6)) \qquad (2)$ $6 = 4 \times 1 + 2 \qquad \text{(notice this is a recursive call of } gcd(6,4)) \qquad (3)$ $4 = 2 \times 2 + 0 \qquad \text{(notice this is a recursive call of } gcd(4,2)) \qquad (4)$ $gcd(16,10) = 2, \text{ the last non-zero remainder. We can also back substitute to } x, y \text{ such that}$ $2 = 16x + 10y = gcd(16,10).$ The is how: Rearrange (3) to get an expression for $gcd(16,10)$: $2 = 6 - 4 \times 1$ $2 = 6 - (10 - 6 \times 1) \times 1$ $3 = 6 + (10 - 6 \times 1) \times 1$ $4 = 6$
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. Idid's algorithm is a fast algorithm for computing the greatest common divisor wo integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (\text{notice this is a recursive call of } gcd(10,6)) \qquad (2)$ $6 = 4 \times 1 + 2 \qquad (\text{notice this is a recursive call of } gcd(6,4)) \qquad (3)$ $4 = 2 \times 2 + 0 \qquad (\text{notice this is a recursive call of } gcd(6,4)) \qquad (4)$ $gcd(16,10) = 2, \text{ the last non-zero remainder. We can also back substitute to } x, y \text{ such that}$ $2 = 16x + 10y = gcd(16,10).$ It is how: Rearrange (3) to get an expression for $gcd(16,10)$: The example of $gcd(16,10)$: $gcd(16,10) = 2 = 6 - 4 \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - (10 - 6 \times 1) \times 1$ $gcd(16,10) = 2 = 6 - 4 \times 1$ $gcd(16,10) $
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 5$ an untiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. Idid's algorithm is a fast algorithm for computing the greatest common divisor we integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad \text{(notice this is a recursive call of } gcd(10,6)) \qquad (2)$ $6 = 4 \times 1 + 2 \qquad \text{(notice this is a recursive call of } gcd(6,4)) \qquad (3)$ $4 = 2 \times 2 + 0 \qquad \text{(notice this is a recursive call of } gcd(4,2)) \qquad (4)$ $gcd(16,10) = 2, \text{ the last non-zero remainder.} \text{ We can also back substitute to } x, y \text{ such that} \qquad 2 = 16x + 10y = gcd(16,10).$ The is how: Rearrange (3) to get an expression for $gcd(16,10)$: The implify: $gcd(16,10)$: The implify: $gcd(16,10)$:
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 5$ as a multiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. Idd's algorithm is a fast algorithm for computing the greatest common divisor wo integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of gcd(10,6)) (2) 6 = 4 \times 1 + 2 \qquad (notice this is a recursive call of gcd(6,4)) (3) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4,2)) (4) gcd(16,10) = 2, \text{ the last non-zero remainder.} \text{ We can also back substitute to} x, y \text{ such that} \qquad 2 = 16x + 10y = gcd(16,10). x, y \text{ such that} \qquad 2 = 16x + 10y = gcd(16,10). x \text{ is in low:} \qquad 2 = 6 - 4 \times 1 x \text{ rearrange (2) to get } 4 = (10 - 6 \times 1) \qquad \text{and substitute:} \qquad 2 = 6 - (10 - 6 \times 1) \times 1 x \text{ simplify:} \qquad 2 = -10 + 6 \times 2 x \text{ now rearrange (1) to get} \qquad 6 = (16 - 10 \times 1) \qquad \text{and substitute:} \qquad 2 = -10 + (16 - 10 \times 1) \times 2 x \text{ simplify:} \qquad 2 = 16 \times 2 - 10 \times 3 x \text{ and } y \text{ and } $
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12, 16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. It is a fast algorithm for computing the greatest common divisor we integers. Here is an example. To compute $gcd(16, 10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of gcd(10, 6)) (2) 6 = 4 \times 1 + 2 \qquad (notice this is a recursive call of gcd(6, 4)) (3) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) gcd(16, 10) = 2, \text{ the last non-zero remainder.} \text{We can also back substitute to} 2 = 16x + 10y = gcd(16, 10). E is how: Rearrange (3) to get an expression for gcd(16, 10): and substitute: 2 = 6 - (10 - 6 \times 1) \times 1 gcd(16, 10) = 2 = 10 + 6 \times 2 gcd(16, 10) = 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10$
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 24$. This gives us $y = 4$. Any multiple of 4 would also work. Bid's algorithm is a fast algorithm for computing the greatest common divisor with one of the property of t
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. Bid's algorithm is a fast algorithm for computing the greatest common divisor wo integers. Here is an example. To compute $gcd(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of gcd(10,6)) (2) 6 = 4 \times 1 + 2 \qquad (notice this is a recursive call of gcd(6,4)) (3) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(6,4)) (4) ycd(16,10) = 2, \text{ the last non-zero remainder.} \text{We can also back substitute to} 2 = 16x + 10y = gcd(16,10). E is how: Rearrange (3) to get an expression for gcd(16,10): 2 = 6 - 4 \times 1 rearrange (2) to get 4 = (10 - 6 \times 1) and substitute: 2 = 6 - (10 - 6 \times 1) \times 1 simplify: 2 = -10 + 6 \times 2 now rearrange (1) to get 6 = (16 - 10 \times 1) and substitute: 2 = -10 + (16 - 10 \times 1) \times 2 simplify: 2 = 16 \times 2 - 10 \times 3 x = 2 and y = -3. To we will practice running Euclid's algorithm. As we saw above, the ith step fuclid's algorithm is of the form a_i = b_i \times q_i + r_i, are a_1 and b_1 are the two numbers for which we are trying to compute the test common divisor. The following questions will ask you to give the values i_i, i_i, i_i, i_i for different steps i. Run Euclid's algorithm to determine the greatest common divisor of a = 8, b = 22. i. In the first step of the algorithm, we have a_1 = 22 and b_1 = 8. Give the values for q_1 and q_1: q_1 = We're solving 22 = 8 \times q_1 + r_1, so r_1 = 22 \mod 8 = 6. ii. What are a_2, b_2, q_2, and r_2? a_2 = Review Euclid's algorithm in the notes. By the algorithm, we're now trying to compute gcd(8,6), so a_2 = 8. b_2 = Review Euclid's algorithm in the notes. By the algorithm, we're now trying to compute gcd(8,6), so b_2 = 6.$
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 16$ and $16 \mod 16$ inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 16$ and $16 \mod 16$ are the two numbers of vointegers. Here is an example. To computing the greatest common divisor wo integers. Here is an example. To computing the greatest common divisor wo integers. Here is an example. To compute $gcd(16, 10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of gcd(10, 6)) (2) 6 = 4 \times 1 + 2 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(4, 2)) (4) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(6, 1)) (5) 2 = 6 \qquad (16 - 10 \times 1) \qquad (16 - 10 \times 1) \qquad (16 + 1$
So g find Here Now of E where greater for a	What is $god(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 2$ as a multiple of 16. To find the smallest such y , solve $12y = lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. It is a fast algorithm for computing the greatest common divisor to integers. Here is an example. To compute $god(16,10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of god(16,4)) (3) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of god(16,4)) (4) god(16,10) = 2, \text{ the last non-zero remainder.} \text{ We can also back substitute to } x, y \text{ such that} \qquad 2 = 16x + 10y = god(16,10). e is how: Rearrange (3) \text{ to get an expression} \qquad \text{ for } god(16,10): \qquad 2 = 6 - 4 \times 1 \text{ rearrange } (2) \text{ to get } 4 = (10 - 6 \times 1) \text{ and substitute:} \qquad 2 = 6 - (10 - 6 \times 1) \times 1 \text{ simplify:} \qquad 2 = -10 + (6 \times 2) \text{ now rearrange } (1) \text{ to get} \qquad 2 = 16 \times 2 - 10 \times 3 \text{ and } y = -3. we will practice running Euclid's algorithm. As we saw above, the ith step nuclid's algorithm is of the form a_i = b_i \times q_i + r_i, for a_i and b_i are the two numbers for which we are trying to compute the extra common divisor. The following questions will ask you to give the values a_i, b_i, a_i, a_i$
So g find Here Now of E where greater for a	What is $gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y = lcm(12, 16) = 48$. This gives $uy = 4$. Any multiple of 4 would also work. did's algorithm is a fast algorithm for computing the greatest common divisor to integers. Here is an example. To compute $gcd(16, 10)$: $16 = 10 \times 1 + 6 \qquad (1)$ $10 = 6 \times 1 + 4 \qquad (notice this is a recursive call of gcd(6, 4)) (3) 4 = 2 \times 2 + 0 \qquad (notice this is a recursive call of gcd(6, 4)) (4) gcd(16, 10) = 2, \text{ the last non-zero remainder}. \text{ We can also back substitute to } x, y \text{ such that} 2 = 16x + 10y = gcd(16, 10). is how: Rearrange (3) to get an expression for gcd(16, 10): 2 = 6 - 4 \times 1 rearrange (2) to gct = 4 = (10 - 6 \times 1) and substitute: 2 = 6 - (10 - 6 \times 1) \times 1 simplify: 2 = -10 + 6 \times 2 simplify: 2 = -10 + (6 - 10 \times 1) \times 2 simplify: 2 = 16 \times 2 - 10 \times 3 3 = 2 \text{ and } y = -3. 4 = b_1 \times q_1 + r_1, re a_1 and b_1 are the two numbers for which we are trying to compute the test common divisor. The following questions will ask you to give the values gcd(16, 10): gcd(16, 10): gcd(16, 10) = \frac{1}{2} + \frac{1}{2}$
So g find Here So x Now of E when greater (a)	What is $god(x, n)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find g such that $12g \equiv 0 \mod 16$, so $12g$ must be a multiple of 16. To find the smallest such g , solve $12g \equiv lcm(12, 16) = 48$. This gives us $g = 4$. Any multiple of 4 would also work. Idid's algorithm is a fast algorithm for computing the greatest common divisor vo integers. Here is an example. To compute $god(16, 10)$: $16 = 10 \times 1 + 6$ (1) $10 = 6 \times 1 + 4$ (notice this is a recursive call of $god(0, 6)$) (2) $6 = 4 \times 1 + 2$ (notice this is a recursive call of $god(6, 4)$) (3) $4 = 2 \times 2 + 0$ (notice this is a recursive call of $god(6, 4)$) (4) $4 = 2 \times 2 + 0$ (notice this is a recursive call of $god(4, 2)$) (4) $eod(16, 10) = 2$, the last non-zero remainder. We can also back substitute to x , y such that $2 = 16x + 10y = god(16, 10)$. Freatrange (3) to get an expression for $god(16, 10)$: $eod(16, 10) = 2$ and $eod(16, 10)$: $eod(1$
So g find Here So x Now of E when greater (a)	What is $god(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y$ must be a multiple of 16. To find the smallest such y , solve $12y \equiv lcm(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. It is algorithm is a fast algorithm for computing the greatest common divisor wo integers. Here is an example. To compute $god(16,10)$: $16 = 10 \times 1 + 6$ (1) $10 = 6 \times 1 + 4$ (notice this is a recursive call of $god(16,0)$) (2) $6 = 4 \times 1 + 2$ (notice this is a recursive call of $god(6,4)$) (3) $4 = 2 \times 2 + 0$ (notice this is a recursive call of $god(4,2)$) (4) $god(16,10) = 2$, the last non-zero remainder. We can also back substitute to x , y such that $2 = 16x + 10y = god(16,10).$ $god(16,10) = 2 = 6 - 4 \times 1$ rearrange (3) to get an expression for $god(16,10)$: $2 = 6 - 4 \times 1$ rearrange (2) to get $4 = (10 - 6 \times 1)$ and substitute: $2 = 6 - (10 - 6 \times 1) \times 1$ simplify: $2 = -10 + 6 \times 2$ now rearrange (1) to get $6 = (16 - 10 \times 1)$ and substitute: $2 = -10 + (16 - 10 \times 1) \times 2$ simplify: $2 = 16 \times 2 - 10 \times 3$ $x = 2$ and $y = -3$. Therefore, we will practice running Euclid's algorithm. As we saw above, the i th step uclid's algorithm is of the form $a_i = b_i \times q_i + r_i,$ for any $a_i = a_i$ of the form of $a_i = a_i$ of
So g find Here So x Now of E when greater (a)	What is $gol(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 16$ and 15 . This gives us $y = 4$. Any multiple of would also work. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 16$ as a multiple of 15 . To find the smallest such y , so we have $y = 4$. Any multiple of 4 would also work. It is algorithm is a fast algorithm for computing the greatest common divisor to integers. Here is an example. To compute $gol(16, 10)$: $16 = 10 \times 11 + 6$ $10 = 6 \times 11 + 4$ (notice this is a recursive call of $gol(16, 0)$) (2) $6 = 4 \times 11 + 2$ (notice this is a recursive call of $gol(16, 0)$) (3) $4 = 2 \times 2 \times 10$ (notice this is a recursive call of $gol(16, 0)$) (4) $gol(16, 10) = 2$, the last non-zero remainder. We can also back substitute to x, y such that $2 = 16x + 10y = gol(16, 10)$. It is how: Rearrange (3) to get an expression for $gol(16, 10)$ of $gol(16, 10)$ and substitute: $2 = 6 - (10 - 6 \times 1) \times 10$ and substitute: $2 = -10 + 6 \times 2$ now rearrange (1) to get $6 = (16 - 10 \times 1)$ and substitute: $2 = -10 + (16 - 10 \times 1) \times 2$ simplify: $2 = 16 \times 2 - 10 \times 3$ $2 = 2$ and $y = -3$. For we will practice running Euclid's algorithm. As we saw above, the i th step uclid's algorithm is of the form $a_1 = b_1 \times a_1 + r_1$, For a_1 and b_1 are the two numbers for which we are trying to compute the test common divisor. The following questions will ask you to give the values b_1, b_2, b_3, c_4, b_4 for different steps b_4, b_4, b_4, c_4, b_4 for b_4, b_4, b_4, b_4, b_4 for $b_4, b_4, b_$
So g find Here So x Now of E when greater (a)	What is $god(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find g such that $12y \equiv 0$ mod 16 , so $12y$ must be a multiple of 4 would also work. We want to find g such that $12y \equiv 0$ mod 16 , so $12y$ must be a multiple of 4 would also work. Bids algorithm is a fast algorithm for computing the greatest common divisor with integers. Here is an example. To compute $god(16, 10)$: $16 = 10 \times 1 + 6$ (1) $10 = 6 \times 1 + 4$ (notice this is a recursive call of $god(10, 6)$) (2) $6 = 4 \times 1 + 2$ (notice this is a recursive call of $god(10, 6)$) (3) $4 = 2 \times 2 + 0$ (notice this is a recursive call of $god(6, 4)$) (4) $eod(16, 10) = 2$, the last non-zero remainder. We can also back substitute to x, y such that $2 = 16x + 10y = god(16, 10)$. Is how: Rearrange (3) to get an expression for $god(10, 10)$: $for god(10, 10): for god(10, 10)$
So g find Here So x Now of E when greater (a)	What is $\gcd(x,m)$? Review the definition and existence conditions of an inverse modulo m in the notes. We want to find q such that $12q \equiv 0$ mod 16 , so $12q$ must be a multiple of 16 . To find the smallest such p , solve $12q = lcm(12, 10) = 48$. This gives $m \neq 0$ 4. Any multiple of 4 would also work. It is a fast algorithm for computing the greatest common divisor ox integers. Here is an example. To compute $gol(16, 10)$: $16 = 10 \times 1 + 6 \qquad (10) = 6 \times 1 + 4 \qquad (10) = 6 \times 1 + 2 \qquad (10) = 6 \times 1 + 2 \qquad (10) = 6 \times 4 + 1 \qquad (20) = 6 \times 4 \qquad (20) = 6 \times $
So g find Here So x Now of E when greater (a)	What is $\gcd(x,m)^*$. Review the definition and existence conditions of an inverse modulo m in the notes. We want to find g such that $12g \equiv 0 \mod 16$, so $12g \mod 16$ as a militiple of 16 . To find the smallest such g , solve $12g = l \mod 16$, so $12g \mod 16$ and 16 . This gives us $g = 4$. Any militiple of 4 would also work. We want to find g and g a
So g find Here So x Now of E when greater (a)	What is $gol(x,m)$? Review the definition and existence conditions of an inverse method in in the notes. We want to find y such that $12y \equiv 0 \mod 16$, so $12y \mod 20$ as a multiple of 16. To find the smallest sade, y solve $12y = l\cos(12,16) = 48$. This gives us $y = 4$. Any multiple of 4 would also work. 16. To find the sain example. To compute $gol(16,10)$: 16. $= 10 \times 1 + 6$ (1) 10. $= 6 \times 1 + 4$ (notice this is a recursive call of $gol(10,6)$) (2) 6. $= 4 \times 1 + 2$ (notice this is a recursive call of $gol(10,6)$) (3) 4. $= 2 \times 2 + 0$ (notice this is a recursive call of $gol(10,6)$) (4) 6. $= 4 \times 1 + 2$ (notice this is a recursive call of $gol(10,6)$) (5) 6. $= 4 \times 1 + 2$ (notice this is a recursive call of $gol(10,6)$) (6) 7. $gol(16,10) = 2$, the last non-zero remainder. We can also back substitute to x , y such that $y = 10 + 10y = gol(16,10)$. 7. $gol(16,10) = 2$, the last non-zero remainder. We can also back substitute to x , y such that $y = 10 + 10y = gol(16,10)$. 8. $gol(16,10) = 2 + 10y = gol(16,10)$. 9. $gol(16,10) = 2 + 10y = gol(16,10)$. 10. $gol(16,10) = 2 + 10y = gol(16,10)$. 11. $gol(16,10) = 2 + 10y = gol(16,10)$. 12. $gol(16,10) = 2 + 10y = gol(16,10)$. 12. $gol(16,10) = 2 + 10y = gol(16,10)$. 13. $gol(16,10) = 2 + 10y = gol(16,10)$. 14. $gol(16,10) = 2 + 10y = gol(16,10)$. 15. $gol(16,10) = 2 + 10y = gol(16,10)$. 16. $gol(16,10) = 2 + 10y = gol(16,10)$. 17. $gol(16,10) = 2 + 10y = gol(16,10)$. 18. $gol(16,10) = 2 + 10y = gol(16,10)$. 19. $gol(16,10) = 2 + 10y = gol(16,10)$. 19. $gol(16,10) = 2 + 10y = gol(16,10)$. 10. $gol(16,10) = 2 + 10y = gol(16,10)$. 11. $gol(16,10) = 2 + 10y = gol(16,10)$. 12. $gol(16,10) = 2 + 10y = gol(16,10)$. 13. $gol(16,10) = 2 + 10y = gol(16,10)$. 14. $gol(16,10) = 2 + 10y = gol(16,10)$. 15. $gol(16,10) = 2 + 10y = gol(16,10)$. 16. $gol(16,10) = 10y = gol(16,10)$. 17. $gol(16,10) = 10y = gol(16,10)$. 18. $gol(16,10) = 10y = gol(16,10)$. 19. $gol(16,10) = 10y = gol(16,10)$. 19. $gol(16,10) = 10y = gol(16,10)$. 19. $gol(16,10)$
So g find Here So x Now of E where greater (a)	What is goffz, m.)? Review the definition and existence conditions of an inverse moduli on its the notes. We want to find y such that $12y \equiv 0$ mod 16 , so $12y$ must be a multiple of 1.5 fo find the smallest such y as 4 . Any multiple of 3 would also work its algorithm is a fast algorithm for computing the greatest common divisor so integers. Here is an example. To compute y of $(16, 10)$: 16 = $10 \times 1 + 6$ (10 = $10 \times 1 + 6$ (11 = $10 \times 1 + 6$ (10 = 10
So g find Here So x Now of E where greater (a)	What is get 2, m/? Review the definition and existence conditions of an inverse modulio in the notes. We want to find y such that 12y = 0 mod 16, so 12y must be a multiple of 1. To find the smallest each y, so vice 12y = (sent [12, 6)) = 48. This give us $y = 4$. Any multiple of 4 would also work. Little 3 departmen is fast algorithm for computing the greatest common divisor on integers. Here is an example. To compute $god(16, 10)$: $16 = 10 \times 1 + 6$ $10 = 6 \times 1 + 4$ $10 = 6 $
So g find Here So x Now of E where greater (a)	What is golfar, wi? Roview the definition and existence conditions of an inverse modulo n in the noises. We want to find g such that $12g = 0$ mod 16 , so $12g$ must be multiple of 1 . To find the smallest sail q , six low $12g$ must be multiple of 1 would also work. In 75 in the smallest sail q would also work. In 10 × 1 + 6 10 = 0
So g find Here So x Now of E where greater (a)	What is $g_1d(x, m)$? Review the definition and estimates contain the motes modulo m in the motes. We want to find g such that $12g \equiv 0$ mod 10 , so $12g$ must be an antique of 1.5. To find the smallest such g , so the $12g = (m/(2/16)) = 48$. This gives $g = 4$. Any multiple of g would also work. 15. To find the smallest such g , so for $12g = (m/(2/16)) = 18$. This gives $g = 4$. Any multiple of g would also work. 16. If $g = 10 \times 1 - 6$ [11] $g = (m/(2/16)) = (m/(2$
So g find Here So x Now of E where greater (a)	What is $g_2(x_1, \alpha_1)$? Review the definition and existence conditions of an inverse modulus or in the notes. We want to find g such that $12g = 0$ and $16, s = 12g$ must be a maliphe of 1.5 . To find the analysis and g , solve $12g = 1$ and $12g$ in the 1.5 To find the analysis of 1.5 To find the analysis of 1.5 To find the analysis of 1.5 To find the smallest sud g , solve $12g = 1$ and 1.5 To
So g find Here So x Now of E where greater (a)	What is geffer, wif? Review the definition and calciumes conditions of an internetic wife variety to find y such that $12y=0$ and 16 , so $12y$ must be a multiple of 1.5 . To find the analised and y, ander $12y=0$ cond $12/10$ = 48 . This gives $y=4$. Any multiple of it would also work. If a finite is mainted in the problem of th
So g find Here So x Now of E where greater (a)	What is equilibrially Review to definition and cisatenes conditions of an inverse modulo to the noise. We want to find y such that $12y \equiv 0$ mod 16, so $12y$ must be a mixture of 16, 16 information and supprise of a would also work. We want to find y such that $12y \equiv 0$ mod 16, so $12y$ must be a mixture of the objective in the analysis of the world side work. We want to find a partition for compute get(1,0): 16 = 10 × 1+4 (other this is a recursive and of port(10,6)) (3): 6 = 4 × 1+2 (other this is a recursive and of port(10,6)) (3): 6 = 4 × 1+2 (other this is a recursive and of port(10,6)) (4): 7 = 2 × 2 × 0 (other this is a recursive and of port(10,6)) (4): 7 = 2 × 2 × 0 (other this is a recursive and of port(10,6)) (4): 8 bows: Recurrency (3): to get an expression: 8 or port(16,10) $2 = 6 - 4 \times 1$ 10 correspon(2): to get $4 + (10 - 6 \times 1)$ 11 correspon(2): to get $4 + (10 - 6 \times 1)$ 12 correspon(2): to get $4 + (10 - 6 \times 1)$ 13 correspon(2): to get $4 + (10 - 6 \times 1)$ 14 correspon(2): to get $4 + (10 - 6 \times 1)$ 15 correspon(2): to get $4 + (10 - 6 \times 1)$ 16 correspon(2): to get $4 + (10 - 6 \times 1)$ 17 correspon(2): to get $4 + (10 - 6 \times 1)$ 18 correspon(2): to get $4 + (10 - 6 \times 1)$ 19 correspon(2): to get $4 + (10 - 6 \times 1)$ 10 correspon(2): to get $4 + (10 - 6 \times 1)$ 10 correspon(2): to get $4 + (10 - 6 \times 1)$ 11 correspon(2): to get $4 + (10 - 6 \times 1)$ 12 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 12 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 13 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 14 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 15 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 16 correspon(2): $4 + (10 - 10 \times 1) \times 2$ 17 correspon(3): $4 + (10 - 10 \times 1) \times 2$ 18 correspon(4): $4 + (10 - 10 \times 1) \times 2$ 19 correspon(4): $4 + (10 - 10 \times 1) \times 2$ 10 correspon(4): $4 + (10 - 10 \times 1) \times 2$ 11 correspon(4): $4 + (10 - 10 \times 1) \times 2$ 12 correspon(5): $4 + (10 - 10 \times 1) \times 2$ 13 correspon(6): $4 + (10 - 10 \times 1) \times 2$ 14 correspon(6): $4 + (10 - 10 \times 1) \times 2$ 15 correspon(6): $4 + (10 - 10 \times 1) \times 2$ 16 correspon(6
So g find Here So x Now of E where greater (a)	What is gelder, will Review the definition and existence conditions of all means modulos in the notes. We want to find y such that $12y \equiv 0$ mod 16 , so $12y$ mosts be a multiple of 1.0 . To find the sembles with y_i active $12y = 0$ mod $12, 160 - 148$. This gives as $y = 4$. Any multiple of it would also work. 16 = 10 × 1 + 4. (croise this is a recurrier to greatest common divisor so attent. Here is an example. To exampte $y \in (10, 10) = 0$ (4) $4 = 2 \times 2 + 0$. (union this is a recurrier cell of $g \in (10, 10) = 0$ (4) $4 = 2 \times 2 + 0$. (union this is a recurrier cell of $g \in (10, 12) = 0$ (5) $4 = 2 \times 2 + 0$. (union this is a recurrier cell of $g \in (10, 12) = 0$ (6) $4 = 1 \times 1 + 0$. 16 $4 = 10 \times 1 + 0$ (10) $4 = 10 \times 1 + 0$ (10) $4 = 10 \times 1 + 0$ (10) $4 = 10 \times 1 + 0$ (11)
So g find Here So x Now of E where greater (a)	What is spoil, and Y . Harview the derivation and relations of an inverse mental to the the cases. We want to find Y such that $YY = 0$ model S_1 to $YY = 0$ model $YY = 0$. The find the models are only as $YY = 0$ models and $YY = 0$ models are only as $YY = 0$. The find $YY = 0$ models are only as $YY = 0$ models are only as $YY = 0$ models are only as $YY = 0$. The find $YY = 0$ models are only as $YY = 0$ mo
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